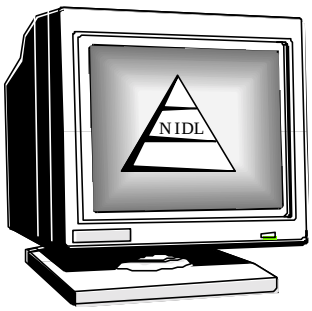


Siemens developed the 21105 monitor as an improved version of the 21103. The 21105 uses a high resolution 5-megapixel electron gun to achieve a finer spot size at 35 fL in the monoscopic mode. Concomitantly, the CRT faceplate transmission was increased from 28% to 42%. NIDL found that the Siemens SMM21105L (Stereo) monitor has improved spot size and contrast modulation compared to the 21103L monitor. We also found, however, that in order to pass all of the IEC WG specifications, the user has to augment the preset Siemens factory default settings with manual adjustments on the front panel of the 21105L monitor. Use of only factory default settings leads to failure to meet the specifications for dynamic range and linearity in monoscopic mode. Linearity was adjusted to be within the IEC specification using Siemens SMfit software; dynamic range was adjusted using the monitor's front panel controls. In stereoscopic mode, the Siemens preset factory default of Lmax = 136 fL does not meet the IEC required level of luminance at the analyst's eye viewpoint. In order to meet the Lmax of >30fL to the analyst's eyes through the ZScreen and passive glasses, the luminance at the CRT faceplate must be increased to 250 fL using the front panel controls. NIDL rates this July 2001 manufacture monitor "A" for both monoscopic and stereoscopic modes for the image analyst IEC workstation application when the factory default settings are augmented with the user adjusted settings.

Evaluation of the SIEMENS SMM 21105 L (STEREO) 4 x 3 Aspect Ratio, 21-Inch Diagonal High Contrast Gray Scale CRT Monitor Manufactured July 2001

National Technology Alliance
National Information Display Laboratory
P. O. Box 8619
Princeton, NJ 08543-8619
Tel: (609) 951-0150
Fax: (609) 734-2313
e-mail: nidl@nidl.org
Publication No. 750810801-125

September 11, 2001

NOTICE:

The National Information Display Laboratory (NIDL) at the Sarnoff Corporation prepared this report. Neither the NIDL nor any person acting on their behalf:

A. Makes any warranty or representation, expressed or implied, with respect to the use of any information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report is free from infringement of any third party rights; or
B. Makes any endorsement of any of the products reported on herein; or
C. Assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
11092001	N/A	-

Title and Subtitle Evaluation of the SIEMENS SMM 21105 L (STEREO) 4 x 3 Aspect Ratio, 21-Inch Diagonal High Contrast Gray Scale CRT Monitor Manufactured July 2001	**Contract Number**
	Grant Number
	Program Element Number
Author(s)	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) National Information Display Laboratory P. O. Box 8619 Princeton, NJ 08543-8619	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es)	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)
Distribution/Availability Statement Approved for public release, distribution unlimited	
Supplementary Notes The original document contains color images.	
Abstract	
Subject Terms	
Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU
Number of Pages 77	

CONTENTS

NIDL IEC Monitor Certification Report

Siemens SMM 21105 L (STEREO) 21-inch High Contrast Gray Scale CRT Monitor (July 2001 Manufacture)

FINAL GRADES
Monoscopic Mode: A
Stereoscopic Mode: A

A=Substantially exceeds IEC Requirements; B= Meets IEC Requirements; C=Nearly meets IEC Requirements; F=Fails to meet IEC Requirements in a substantial way

Siemens developed the 21105 monitor as an improved version of the 21103. The 21105 uses a high resolution 5-megapixel electron gun to achieve a finer spot size at 35 fL in the monoscopic mode. Concomitantly, the CRT faceplate transmission was increased from 28% to 42%.

NIDL found that the Siemens SMM21105L (Stereo) monitor has improved spot size and contrast modulation compared to the 21103L monitor. We also found, however, that in order to pass all of the IEC WG specifications, the user has to augment the preset Siemens factory default settings with manual adjustments on the front panel of the 21105L monitor.

Use of only factory default settings leads to failure to meet the specifications for dynamic range and linearity in monoscopic mode. Linearity was adjusted to be within the IEC specification using Siemens SMfit software; dynamic range was adjusted using the monitor's front panel controls.

In stereoscopic mode, the Siemens preset factory default of Lmax = 136 fL does not meet the IEC required level of luminance at the analyst's eye viewpoint. In order to meet the Lmax of >30fL to the analyst's eyes through the ZScreen and passive glasses, the luminance at the CRT faceplate must be increased to 250 fL using the front panel controls

The appearance of the unpowered screen on the 21105 and the 21103 monitors is different; the 21105 appears lighter while the 21103 appears darker perhaps due to the phosphors on 42% versus 28% transmission glass. Importantly, according to NIDL's measurements, screen reflectance of the 21105 monitor is higher compared to the 21103 (20% vs. 7%) so use in a dark room is preferred. Use in office lighting will produce more recognizable reflections on the 21105 that may distract the analyst.

The Siemens web site is http://www1.ad.siemens.de/monitors/index_76.htm.
The StereoGraphics web site is http://www.stereographics.com/.

Details of the measurements are summarized below:

Contrast Ratio

- FACTORY DEFAULT: Full screen white-to-black contrast ratio measured in 1600 x 1200 format is 254:1 (24.1 dB dynamic range) in a dark room. It decreases to under 158:1 (22 dB), the absolute threshold for IEC, in less than 1 fc diffuse ambient illumination.
- USER ADJUSTED: Full screen white-to-black contrast ratio measured in 1600 x 1200 format is 362:1 (25.6 dB dynamic range) in a dark room. It decreases to under 158:1 (22 dB), the absolute threshold for IEC, in less than 1 fc diffuse ambient illumination.

Maximum Luminance

- FACTORY DEFAULT: The highest luminance for Lmax was 37.9 fL measured at screen center in 1600 x 1200 format for monoscopic mode. The highest luminance for Lmax was 136 fL measured at screen center in 1024 x 1024 format for stereoscopic mode.
- USER ADJUSTED: The highest luminance for Lmax was 250 fL measured at screen center in 1024 x 1024 format for stereoscopic mode to achieve > 30 fL through the ZScreen and passive glasses to the analyst's eye position.

Tonal Transfer Curve

- FACTORY DEFAULT: In monoscopic mode, positive increases in luminance were measured for each of the 256 input levels for 8 bits of gray scale. Neither black level clipping nor white level saturation was observed. NIDL measured between 1 and 3 JNDs between each of the 256 gray levels.

Artifacts

- No video artifacts were observed factory default and user adjusted settings for Lmax luminance values ranging from 35 fL to 250 fL at the CRT.

Contrast Modulation

- FACTORY DEFAULT: In 1600 x 1200 monoscopic mode, contrast modulation (Cm) for 1-on/1-off grille patterns displayed at 50% Lmax (Lmax= 37.9 fL) exceeded Cm = 74% in Zone A, and exceeded Cm = 65% in Zone B.
- Contrast modulation for the raster in a full white screen is 51% and appeared more prominent compared to the 21103 monitor.
- These values for Cm far exceed the IEC requirements.

Stereoscopic Extinction Ratio and Luminance

- FACTORY DEFAULT: Using the factory default settings, the monitor did not have sufficient luminance (Lmax = 17.1fL) at the analyst's eye point to pass the IEC requirement of 30fL for stereoscopic mode through the ZScreen and passive glasses.
- Stereo extinction ratio for the ZScreen and passive polarized glasses averaged 33.1 to 1 (41.1 left, 25.4 right) at screen center.
- Stereo extinction ratio for the active polarized LC shutter glasses averaged 83.7 to 1 (86.7 left, 80.7 right) at screen center.
- The extinction ratio for the ZScreen/passive glasses, and for the CrystalEyes active shutter glasses exceeded the IEC minimum value of 20:1.

- USER ADJUSTED: The Siemens 21105L monitor passes the IEC requirements for stereoscopic mode only when user adjustments are made to increase the luminance beyond the Siemens factory preset Lmax to achieve IEC required 30 fL threshold at the analyst's eye.
- With Lmax set to 250 fL at the CRT screen to achieve 34 fL at the analyst's eye viewpoint, stereo extinction ratio for the ZScreen and passive polarized glasses averaged 31.0 to 1 (38.4 left, 23.6 right) at screen center. Luminance of white varied by up to 18.6% across the screen.

Linearity of Scan

- FACTORY DEFAULT: The maximum nonlinearity of scan for the default factory setting was -2.34% of full screen and did not meet the IEC requirement of 1.0% or less.
- USER ADJUSTED: The Horizontal S-Correction adjustment in SMfit was used to successfully reduce the linearity to -0.7% in order to pass the IEC requirement.

Jitter

- FACTORY DEFAULT: For monoscopic mode at 1600 x 1200 x 75 Hz, maximum jitter and swim/drift were 1.85 mils and 2.05 mils, respectively, and are well within the IEC specifications.

Screen Reflectance

- The 21105 (July 2001 manufacture) measured 20% total reflectance compared to only 10% for the 21105 (May 2001 manufacture) and only 7% for the 21103/PIC 21si monitor.
- The components of this reflectance measure 7.4% diffuse, 2.1% specular, and 11% from other components such as haze.

Luminance Stability

- FACTORY DEFAULT: Luminance of full screen white in 1024 x 1024 stereo mode is very stable, decreasing by less than 1% from 135.1fL to 133.8 fL as fill factor (target size) was reduced to 10% of full screen.
- USER ADJUSTED: With Lmax user adjusted to 250 fL at the CRT screen to achieve IEC required 30 fL threshold at the analyst's eye, maximum luminance decreased during the first 3 hrs by 5.3% from 246 fL to 233 fL. After a three-hour stabilization period, the luminance remained extremely constant (within <1%) for the remaining 5 hours of the test.

Briggs Scores

- FACTORY DEFAULT: For the factory default 1600 x 1200 x 75 Hz monoscopic mode at 37.9 fL, Briggs Scores for the BTP #4 Delta-1, Delta-3, Delta-7 and Delta-15 contrast ratio target sets averaged 15, 58, 69, and 88, respectively.
- USER ADJUSTED: For the 1024 x 1024 x 121 Hz stereoscopic mode with Lmax user adjusted to 250 fL at the CRT screen to achieve the IEC required 30 fL threshold at the analyst's eye, Briggs Scores through the ZScreen for the BTP #4 Delta-1, Delta-3, Delta-7 and Delta-15 contrast ratio target sets averaged 19, 57, 64, and 80, respectively.
- The 250 fL setting in stereoscopic mode does not seriously degrade Briggs scores compared to the 37.9 fL setting in monoscopic mode.

Spot Size

- While there are no IEC requirements for spot size and shape measurements, these two parameters directly affect the raster modulation and the 1-on/1-off contrast modulation

observed. The intention of the 21105 monitor is to achieve a finer spot size, particularly in monoscopic mode, compared to the 21103 monitor. A finer spot size will improve resolution and, consequently, increase Briggs scores through higher contrast modulation.

- FACTORY DEFAULT: Using the factory default setting in 1600 x 1200 monoscopic mode with Lmax = 37.8 fL, the spot size (FWHM) is 7.3 H x 4.6 V mils (RAR = 0.75 H x 0.47 V) at screen center.
- Using the factory default setting in 1024 x 1024 stereoscopic mode with Lmax = 136 fL, the spot size (FWHM) is 12.7 H x 6.9 V mils (RAR = 1.08 H x 0.62 V) at screen center.
- USER ADJUSTED: In 1024 x 1024 stereoscopic mode with Lmax user-adjusted to 250 fL,, the spot size (FWHM) is 16.0 H x 9.2 V mils (RAR = 1.36 H x 0.83 V) at screen center.
- For all formats tested, spot shapes exhibit astigmatism in Zone B along the outside edges of the screen.

Line Width

- FACTORY DEFAULT: Linewidths (full width half maximum) were measured at screen center for four luminance settings in the 1600 x 1200 x 75 Hz monoscopic mode. They are 7.84 mils Horizontal x 5.58 mils Vertical at 50% Lmax (19 fL) for a Resolution-Addressability-Ratio of 0.81 H x 0.57 V in monoscopic mode (1600 x 1200).

Evaluation Datasheet - With User Adjustments

Mode	IEC Requirement	Measurement	Compliance
MONOSCOPIC			
Addressability	1024 x 1024 min.	1600 x 1200	Pass
Dynamic Range	25.4 dB	362:1 (25.6 dB)	Pass
Luminance (Lmin)	0.1 fL min. ± 4%	0.1 fL	Pass
Luminance (Lmax)	35 fL ± 4%	36.16 fL	Pass
Uniformity (Lmax)	28% max.	21.4%	Pass
Halation	3.5% max.	2.4%	Pass
Color Temp	Not specified	11821 K	N / A
Reflectance	Not specified	20.5% total 7.4% diffuse only 2.1% specular only	N / A
Bit Depth	8-bit± 5 counts	8-bit	Pass
Step Response	No visible ringing	Clean	Pass
Uniformity (Chromaticity)	0.010 ± 0.005 Δu'v' max.	<0.005 Δu'v'	Pass
Pixel aspect ratio	Square, H = V± 6%	H = V± 0.1%	Pass
Screen size, viewable diagonal	17.5 to 24 inches± 2 mm	19.485 ins.	Pass
Cm, Zone A, 7.6 inch dia.	35% min.	74% H x 87% V	Pass
Cm, Zone A, 40% area	35% min.	76% H x 90% V	Pass
Cm, Zone B	20% min.	65% H x 81% V	Pass
Cm, at center for raster at Lmax	Not specified	51% V	
Pixel density	72 ppi min.	103 ppi	Pass
Straightness	0.5% max. ± 0.05 mm	0.45%	Pass
Linearity	1.0% max. ± 0.05 mm	-0.70%	Pass
Jitter	2 ± 2 mils max.	1.85 mils (m)	Pass
Swim, Drift	5 ± 2 mils max.	2.05 mils (m)	Pass
Warmup time, Lmin to +/- 50%	30 ± 0.5 minutes max.	22 mins.	Pass
Warmup time, Lmin to +/- 10%	60 ± 0.5 minutes max.	58 mins.	Pass
Refresh	72 ±1 Hz min. 60 ±1 Hz absolute minimum	Set to 75 Hz	Pass
Linewidth, 50% Lmax, Center	No specification	7.84 H x 5.58 V mils(m)	N / A
RAR, 50% Lmax, Center	No specification	0.81 H x 0.57 V	N / A
Spot Size, Lmax, Center	No specification	7.3 H x 4.6 V mils(m)	N / A
Briggs Scores BTP#4 Contrast Delta-1, 3, 7, 15	No specification	Delta-1 = 15 Delta-3 = 58 Delta-7 = 69 Delta-15 = 88	N / A
STEREOSCOPIC			
Addressability	1024 x 1024 min.	1024 x 1024	Pass
Lmin	0.1 fL min. ± 4%	0.094 fL (Z)	Pass
Lmax	30 fL min. ± 4%	34.4. fL (Z)	Pass
Dynamic range	24.77 dB min	25.6. dB (Z)	Pass
Uniformity (Chromaticity)	0.02 ± 0.005 Δ u'v' max.	0.008 delta u'v'	Pass
Refresh rate	60 Hz per eye, min	60.5 Hz, per eye	Pass
Extinction Ratio	20:1 min	31.0:1 (Z)	Pass
Spot Size, Lmax, Center	No specification	16.0 H x 9.2 V mils(m)	N / A
Briggs Scores BTP#4 Contrast Delta-1, 3, 7, 15	No specification	Delta-1 = 19 Delta-3 = 57 Delta-7 = 64 Delta-15 = 80	N / A
Luminance Stability vs Fill Factor	No specification	1%	N / A
AMBIENT LIGHTING			
Dynamic Range 22 dB (158:1)	No specification	< 1fc	N / A
Dynamic Range17.8 dB (60:1)	No specification	< 3fc	N / A

(z) denotes StereoGraphics LCD ZScreen and its passive glasses (m) 1 mil = 0.001 inch

Evaluation Datasheet - Factory Default Settings

Mode	IEC Requirement	Measurement	Compliance
MONOSCOPIC			
Addressability	1024 x 1024 min.	1600 x 1200	Pass
Dynamic Range	25.4 dB	254:1 (24.1 dB) [d]	Fail
Luminance (Lmin)	0.1 fL min. ± 4%	0.149 fL [d]	Fail
Luminance (Lmax)	35 fL ± 4%	37.9 fL [d]	Pass
Uniformity (Lmax)	28% max.	21.4%	Pass
Halation	3.5% max.	2.4%	Pass
Color Temp	Not specified	11821 K	N / A
Reflectance	Not specified	20.5% total 7.4% diffuse only 2.1% specular only	N / A
Bit Depth	8-bit± 5 counts	8-bit	Pass
Step Response	No visible ringing	Clean	Pass
Uniformity (Chromaticity)	0.010 ± 0.005 Δu'v' max.	<0.005 Δu'v'	Pass
Pixel aspect ratio	Square, H = V± 6%	H = V± 0.1%	Pass
Screen size, viewable diagonal	17.5 to 24 inches± 2 mm	19.485 ins.	Pass
Cm, Zone A, 7.6 inch dia.	35% min.	74% H x 87% V	Pass
Cm, Zone A, 40% area	35% min.	76% H x 90% V	Pass
Cm, Zone B	20% min.	65% H x 81% V	Pass
Cm, at center for raster at Lmax	Not specified	51% V	
Pixel density	72 ppi min.	103 ppi	Pass
Straightness	0.5% max. ± 0.05 mm	0.45%	Pass
Linearity	1.0% max. ± 0.05 mm	-2.34% [d]	Fail
Jitter	2 ± 2 mils max.	1.85 mils [m]	Pass
Swim, Drift	5 ± 2 mils max.	2.05 mils [m]	Pass
Warmup time, Lmin to +/- 50%	30 ± 0.5 minutes max.	22 mins.	Pass
Warmup time, Lmin to +/- 10%	60 ± 0.5 minutes max.	58 mins.	Pass
Refresh	72 ±1 Hz min. 60 ±1 Hz absolute minimum	Set to 75 Hz	Pass
Linewidth, 50% Lmax, Center	No specification	7.84 H x 5.58 V mils[m]	N / A
RAR, 50% Lmax, Center	No specification	0.81 H x 0.57 V	N / A
Spot Size, Lmax, Center	No specification	7.3 H x 4.6 V mils[m]	N / A
Briggs Scores BTP#4 Contrast Delta-1, 3, 7, 15	No specification	Delta 1 = 15 Delta 3 = 58 Delta 7 = 69 Delta 15 = 88	N / A
STEREOSCOPIC			
Addressability	1024 x 1024 min.	1024 x 1024	Pass
Lmin	0.1 fL min. ± 4%	0.026 fL [Z],0.035 fL [c]	Fail
Lmax	30 fL min. ± 4%	17.1. fL [Z],21.0. fL [c]	Fail
Dynamic range	24.77 dB min	28.2. dB [Z] ,27.8. dB [c]	Pass
Uniformity (Chromaticity)	0.02 ± 0.005 Δ u'v' max.	0.008 delta u'v'	Pass
Refresh rate	60 Hz per eye, min	60.5 Hz, per eye	Pass
Extinction Ratio	20:1 min	33.3:1 [Z] ,83.7:1 [c]	Pass
Spot Size, Lmax, Center	No specification	12.7 H x 6.9 V mils[m]	N / A
Luminance Stability vs Fill Factor	No specification	1%	N / A
AMBIENT LIGHTING			
Dynamic Range 22 dB (158:1)	No specification	< 1fc	N / A
Dynamic Range17.8 dB (60:1)	No specification	< 3fc	N / A

[d] Monitor BRIGHTNESS and CONTRAST and LINEARITY controls set by factory default.
[z] denotes StereoGraphics LCD ZScreen and its passive glasses

(c) denotes Stereographics CrystalEyes wireless IR active LC shutter glasses (m) 1 mil = 0.001 inch

Section I INTRODUCTION

The National Information Display Laboratory (NIDL) was established in 1990 to bring together technology providers - commercial and academic leaders in advanced display hardware, softcopy information processing tools, and information collaboration and communications techniques - with government users. The Sarnoff Corporation in Princeton, New Jersey, a world research leader in high-definition digital TV, advanced displays, computing and electronics, hosts the NIDL.

The present study evaluates a production unit of the Model SMM 21105L (Stereo) 21-inch monochrome CRT high-resolution display monitor manufactured by Siemens. This report is intended for both technical users, such as system integrators, monitor designers, and monitor evaluators, and non-technical users, such as image analysts, software developers, or other users unfamiliar with detailed monitor technology.

The IEC requirements, procedures and calibrations used in the measurements are detailed in the following:

- *NIDL Publication No. 0201099-091, Request for Evaluation Monitors for the National Imagery & Mapping Agency (NIMA) Integrated Exploitation Capability (IEC)*, August 25, 1999.

Two companion documents that describe how the measurements are made are available from the NIDL and the Defense Technology Information Center at http://www.dtic.mil:

- *NIDL Publication No. 171795-036 Display Monitor Measurement Methods under Discussion by EIA (Electronic Industries Association) Committee JT-20 Part 1: Monochrome CRT Monitor Performance Draft Version 2.0. (ADA353605)*
- *NIDL Publication No. 171795-037 Display Monitor Measurement Methods under Discussion by EIA (Electronic Industries Association) Committee JT-20 Part 2: Color CRT Monitor Performance Draft Version 2.0. (ADA341357)*

Other procedures are found in a recently approved standard available from the Video Electronics Standards Association (VESA) at http://www.vesa.org:

- *VESA Flat Panel Display Measurements Standard, Version 1.0, May 15, 1998.*
- *VESA Flat Panel Display Measurements Standard, Version 2.0, June, 2001.*

The IEC workstation provides the capability to display image and other geospatial data on either monochrome or color monitors, or a combination of both. Either of these monitors may be required to support stereoscopic viewing. Selection and configuration of these monitors will be made in accordance with mission needs for each site. NIMA users will select from monitors included on the NIMA-approved Certified Monitor List compiled by the NIDL. The color and monochrome, monoscopic and stereoscopic, monitor requirements are listed in the Evaluation Datasheet.

I.1 The Siemens SMM 21105L (Stereo) Monochrome CRT Monitor

Manufacturer's Specifications as of June 2001; please refer to Siemens web page for current specifications at www.siemens.com/monitors

- CRT with anti-reflective and anti-static panel and dispenser cathode for long CRT life
- Automatic calibration of black level without external sensor every 12 hours
- Constant gamma for equal gray scale performance in multi-monitor configurations
- High brightness and contrast, high resolution CRT up to 235 fL
- 1600 x 1280 addressability monoscopic standard,
- 1024 x 1024 pixel addressability stereo
- Scan range 70 to 135 kHz horizontal, 50 to 130 Hz vertical
- Ambient light sensor for automatic contrast control

Manufacturer's Technical Data as of June 2001; please refer to Siemens web page for current specifications at www.siemens.com/monitors

- Power consumption 150W
- 21 inch CRT flat and square landscape, 90 degree deflection, 42% light transmission
- P45 cadmium free phosphor
- BNC input connectors
- Static and dynamic focus
- 280 MHz pixel clock
- Impedance 75 ohms
- Video level 0.75 to 1.2 V peak to peak
- Sync level 0.1 to 0.5 V peak to peak
- Front panel controls for on/off, contrast, brightness; geometry; ambient light sensor
- Operating temperature 10 to 35C
- Operating humidity 20 to 80%

I.2. Initial Monitor Set Up

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5, p 5.

Per recommendations from the manufacturer and to assure that the monitor was set up to the manufacturer's specifications, the monitor was powered ON and allowed to automatically self-adjust to the factory default settings including the Brightness and Contrast controls which determine the luminance values for Lmin and Lmax as well as the contrast ratio.

All measurements will be made with the display commanded through a laboratory grade programmable test pattern generator. The system will be operated in at least a 24 bit mode (as opposed to a lesser or pseudo-color mode) for color and at least 8 bits for monochrome. As a first step, refresh rate should be measured and verified to be at least 72 Hz. The screen should then be commanded to full addressability and Lmin set to 0.1 fL. Lmax should be measured at screen center with color temperature between D65 and D93 allowable and any operator adjustment of gain allowable. If a value >35fL is not achieved (>30 fL for color), addressability should be lowered. For a nominal 1200 by 1600 addressability, addressability should be lowered to 1280 by 1024 or to 1024 by 1024. For a nominal 2048 by 2560 addressability, addressabilities of 1200 x 1600 and 1024 x 1024 can be evaluated if the desired Lmax is not achieved at full addressability.

I.3. Equipment

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0 Section 2.0, page 3.

The procedures described in this report should be carried out in a darkened environment such that the stray luminance diffusely reflected by the screen in the absence of electron-beam excitation is less than 0.003 cd/m^2 (1mfL).

Instruments used in these measurements included:

- Quantum Data 8701 400 MHz programmable test pattern signal generator
- Photo Research SpectraScan PR-650 spectroradiometer
- Photo Research SpectraScan PR-704 spectroradiometer
- Minolta LS-100 Photometer
- Minolta CA-100 Colorimeter
- Graseby S370 Illuminance Meter
- Microvision Superspot 100 Display Characterization System which included: OM-1 optic module (Two Dimensional photodiode linear array device, projected element size at screen set to 1.3 mils with photopic filter), OM-5 optic module (Two Dimensional CCD linear array device, projected element size at screen set to 0.21 mils with photopic filter), and Spotseeker 4-Axis Positioner.

Stereoscopic-mode measurements were made using the following commercially available stereo products:

- StereoGraphics 19-inch LCD ZScreen with passive polarized eyeglasses.
- StereoGraphics active shutter glasses.

Section II PHOTOMETRIC MEASUREMENTS

II.1. Dynamic Range and Screen Reflectance

References: *Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.6, p 6.*

VESA Flat Panel Display Measurements Standard, Version 1.0, May 15, 199, Section 308-1.

FACTORY DEFAULT: Full screen white-to-black contrast ratio measured in 1600 x 1200 format is 254:1 (24.1 dB dynamic range) in a dark room. It decreases to under 158:1 (22 dB), the absolute threshold for IEC, in less than 1 fc diffuse ambient illumination.

USER ADJUSTED: Full screen white-to-black contrast ratio measured in 1600 x 1200 format is 362:1 (25.6 dB dynamic range) in a dark room. It decreases to under 158:1 (22 dB), the absolute threshold for IEC, in less than 1 fc diffuse ambient illumination.

Objective: Measure the photometric output (luminance vs. input command level) at Lmax and Lmin in both dark room and illuminated ambient conditions.

Equipment: Photometer, Integrating Hemisphere Light Source or equivalent

Procedure: Luminance at center of screen is measured for input counts of 0 and Max Count. Test targets are full screen (flat fields) where full screen is defined addressability. Set Lmin to 0.1 fL. For color monitors, set color temperature between D_{65} to D_{93}. Measure Lmax.

This procedure applies when intended ambient light level measured at the display is 2fc or less. For conditions of higher ambient light level, Lmin and Lmax should be measured at some nominal intended ambient light level (e.g., 18-20 fc for normal office lighting with no shielding). This requires use of a remote spot photometer following procedures outlined in reference 2, paragraph 308-2. This will at best be only an approximation since specular reflections will not be captured. A Lmin > 0.1 fL may be required to meet grayscale visibility requirements.

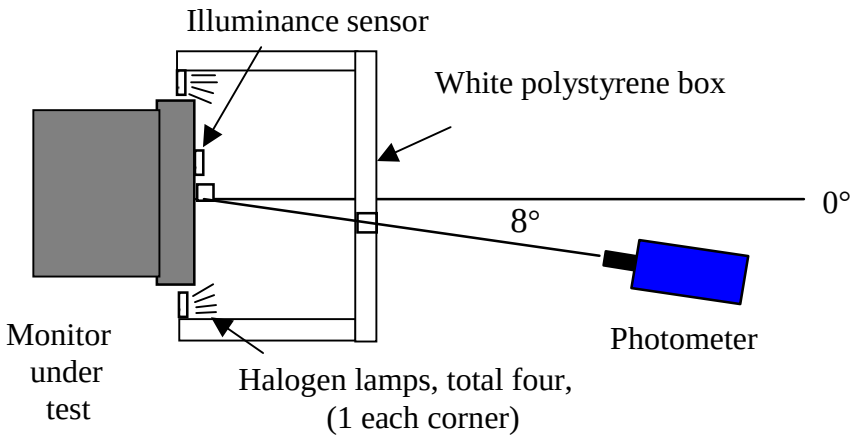
According to the VESA directed hemispherical reflectance (DHR) measurement method, total combined reflections due to specular, haze and diffuse components of reflection arising from uniform diffuse illumination are simultaneously quantified as a fraction of the reflectance of a perfect white diffuse reflector using the set up depicted in figure II.1-1. Total reflectance was calculated from measured luminances reflected by the screen (display turned off) when uniformly illuminated by an integrating hemisphere simulated using a white polystyrene box. Luminance is measured using a spot photometer with 1° measurement field and an

illuminance sensor as depicted in Figure II.1-1. The measured values and calculated reflectances are given in Table II.1-1.

Data: Contrast ratio is a linear expression of Lmax to Lmin. Dynamic range expresses the contrast ratio in log units, dB, which correlates more closely with the sensitivity of the human vision system.

Define contrast ratio by: CR = Lmax/Lmin

Define dynamic range by: DR = 10log(Lmax/Lmin)



- Top View -

Figure II.1-1. Test setup according to VESA FPDM procedures for measuring total reflectance of screen.

Table II.1-1. Directed Hemispherical Reflectance (DHR) of Faceplate
VESA ambient contrast illuminance source (polystyrene box)

Ambient Illuminance	20.08 fc
Reflected Luminance	4.12 fL
Faceplate Reflectance	20.5 %

Ambient dynamic ranges of full screen white-to-black given in Table II.1-2 were computed for various levels of diffuse ambient lighting using the measured value for DHR and the darkroom dynamic range measurements. Full screen white-to-black decreases from 254:1 (24.1 dB dynamic range) in a dark room to less than 22 dB (the absolute threshold for IEC) in less than 1 fc diffuse ambient illumination.

Table II.1-2.Dynamic Range in Dark and Illuminated Rooms

Effect of ambient lighting on dynamic range is calculated by multiplying the measured CRT faceplate reflectivity times the ambient illumination measured at the CRT in foot candles added to the minimum screen luminance, Lmin, where Lmin = 0.149 fL as measured for the factory default setting for the Siemens 21105L monitor. The Lmin is reduced to 0.1 fL for the user adjusted setting.

	FACTORY DEFAULT		USER ADJUSTED	
Ambient Illumination	**Contrast Ratio**	**Dynamic Range**	**Contrast Ratio**	**Dynamic Range**
0 fc (Dark Room)	254 :1	24.1 dB	362 :1	25.6 dB
1 fc	108 :1	20.3 dB	119 :1	20.8 dB
2 fc	68 :1	18.4 dB	72 :1	18.6 dB
3 fc	50 :1	17.0 dB	51 :1	17.1 dB
4 fc	40 :1	16.0 dB	40 :1	16.0 dB
5 fc	33 :1	15.2 dB	33 :1	15.2 dB
6 fc	28 :1	14.5 dB	28 :1	14.5 dB
7 fc	25 :1	13.9 dB	25 :1	13.9 dB
8 fc	22 :1	13.4 dB	22 :1	13.4 dB
9 fc	20 :1	13.0 dB	20 :1	12.9 dB
10 fc	18 :1	12.6 dB	18 :1	12.5 dB
11 fc	17 :1	12.2 dB	16 :1	12.1 dB
12 fc	15 :1	11.9 dB	15 :1	11.8 dB
13 fc	14 :1	11.6 dB	14 :1	11.5 dB
14 fc	13 :1	11.3 dB	13 :1	11.2 dB
15 fc	13 :1	11.0 dB	12 :1	10.9 dB

Spectral distributions plotted in Figure II.1-2 of both the phosphor and screen reflectance (due to incandescent lamps) is about the same for both the May 2001 manufacture and July 2001 manufacture Siemens 21105L monitors. The only difference is a factor of approximately 2 increased reflectivity of the July 2001 screen. The 2X increase applies to the total reflectance as well as the specular-only reflectance and diffuse-only reflectance presented in section II.21 of this report. The 21105 July measured 20% total reflectance compared to only 10% for the 21105 May 2001 manufacture and only 7% for the 21103 monitor.

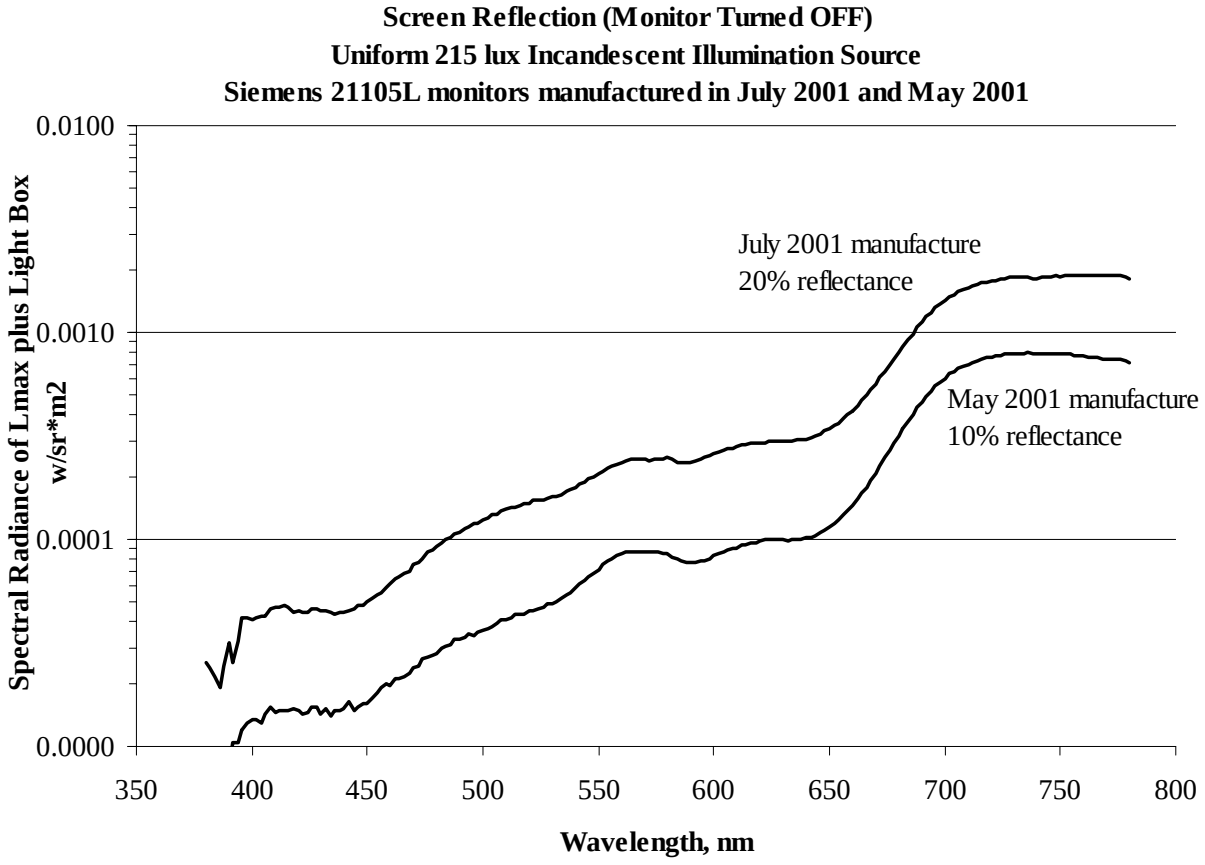


Figure II.1-2. Spectral distributions of screen reflectance (due to incandescent lamps) for the May 2001 manufacture and July 2001 manufacture Siemens 21105L monitors.

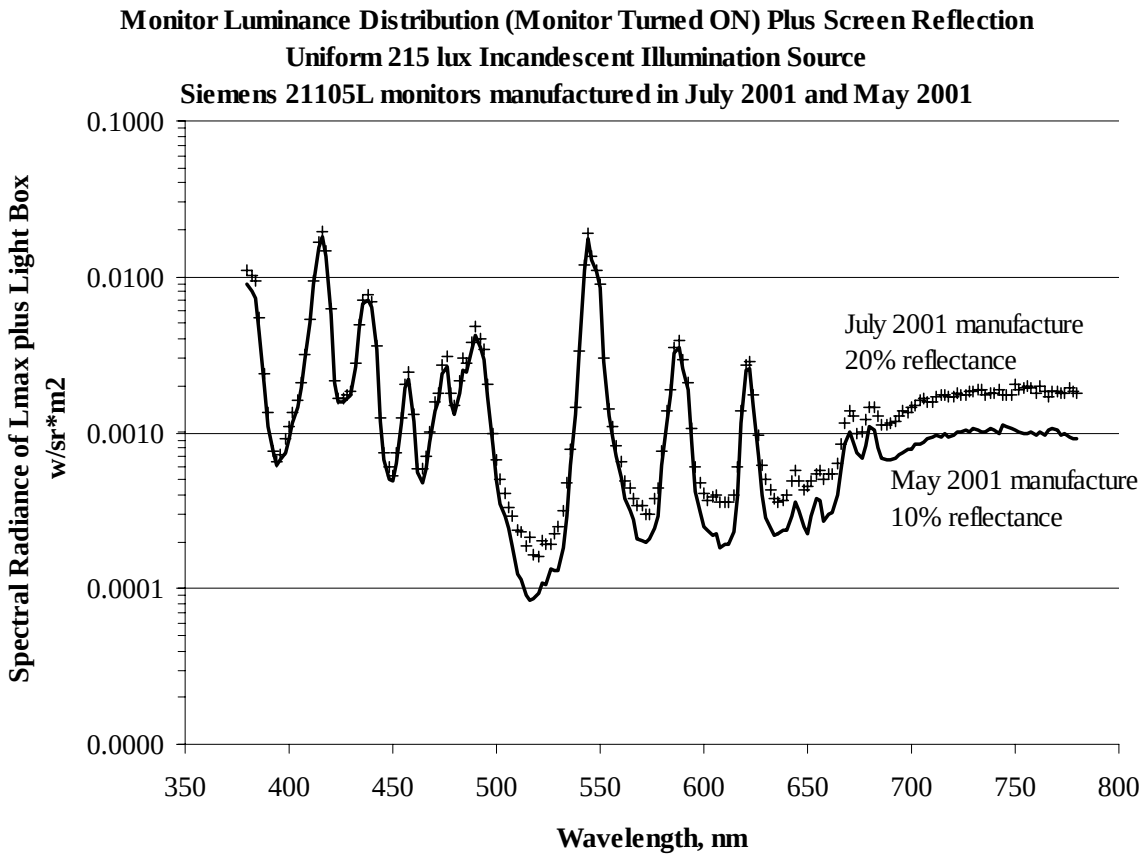


Figure II.1-3. Spectral distributions of monitor luminance in addition to screen reflectance (due to incandescent lamps) for the May 2001 manufacture and July 2001 manufacture Siemens 21105L monitors.

II.2. Maximum Luminance (Lmax)

References: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.2, p 6.

FACTORY DEFAULT: The highest luminance for Lmax was 37.9 fL measured at screen center in 1600 x 1200 format for monoscopic mode. The highest luminance for Lmax was 136 fL measured at screen center in 1024 x 1024 format for stereoscopic mode.

USER ADJUSTED: The highest luminance for Lmax was 250 fL measured at screen center in 1024 x 1024 format for stereoscopic mode to achieve > 30 fL through the ZScreen and passive glasses to the analyst's eye position.

Objective: Measure the maximum output display luminance.

Equipment: Photometer

Procedure: See dynamic range. Use the value of Lmax defined for the Dynamic Range measurement.

Data: The maximum output display luminance, Lmax, and associated CIE x, y chromaticity coordinates (CIE 1976) were measured using a hand-held colorimeter (Minolta CA-100).

Table II.2-1. Maximum Luminance and Color

Color and luminance (in fL) for Full screen at 100% Lmax taken at screen center.

Format	CCT	CIE x	CIE y	Luminance
FACTORY DEFAULT				
1600 x 1200	11821	0.251	.0307	37.9 fL
1024 x 1024				136 fL
USER ADJUSTED				
1024 x 1024				250 fL

II.3. Luminance (Lmax) and Color Uniformity

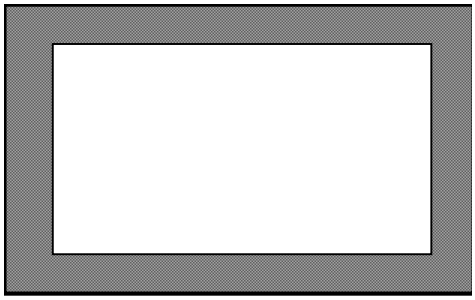
Reference: Monochrome CRT Monitor Performance, Draft Version 2.0, Section 4.4, p. 28.

For the factory default monoscopic mode of 37.9 fL at screen center, maximum luminance (Lmax) varied by up to 21.4% across the screen. Chromaticity variations were less than 0.005 delta u'v' units.

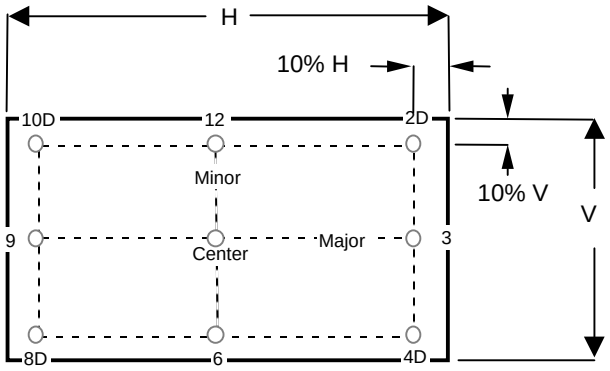
Objective: Measure the variability of luminance and chromaticity coordinates of the white point at 100% Lmax only and as a function of spatial position. Variability of luminance impacts the total number of discriminable gray steps.

Equipment:
- Video generator
- Photometer
- Spectroradiometer or Colorimeter

Test Pattern: Full screen flat field with visible edges at L_{min} as shown in Figure II.3-1.



Full Screen Flat Field test pattern.
Figure II.3-1



Nine screen test locations.
Figure II.3-2

Procedure: Investigate the temporal variation of luminance and the white point as a function of intensity by displaying a full flat field shown in Figure II.3-1 for video input count levels corresponding L_{max}. Measure the luminance and C.I.E. color coordinates at center screen.

Investigate the temporal variation of luminance and the white point as a function of spatial position by repeating these measurements at each of the locations depicted in Figure II.3-2. Define color uniformity in terms of $\Delta u'v'$.

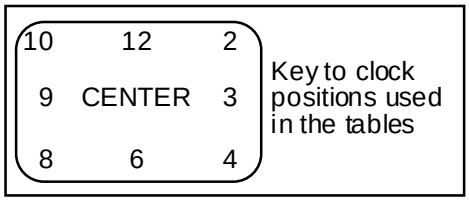
Data: Tabulate the luminance and 1931 C.I.E. chromaticity coordinates (x, y) or correlated color temperature of the white point at each of the nine locations depicted in Figure II.3-2. Additionally, note the location of any additional points that are measured along with the corresponding luminance values.

Table II.3-1.Spatial Uniformity of Luminance and Color

Color and luminance (in fL) for full screen at 100% Lmax taken at nine screen positions.

1600 x 1200

POSITION	CCT	CIE x	CIE y	L, fL
center	11821	0.251	0.307	37.9
2	12582	0.248	0.301	34.3
3	12393	0.249	0.302	29.8
4	12471	0.249	0.301	31.2
6	12393	0.249	0.302	29.9
8	12664	0.248	0.300	34.4
9	12393	0.249	0.302	30.8
10	12582	0.248	0.301	31.0
12	12393	0.249	0.302	30.2



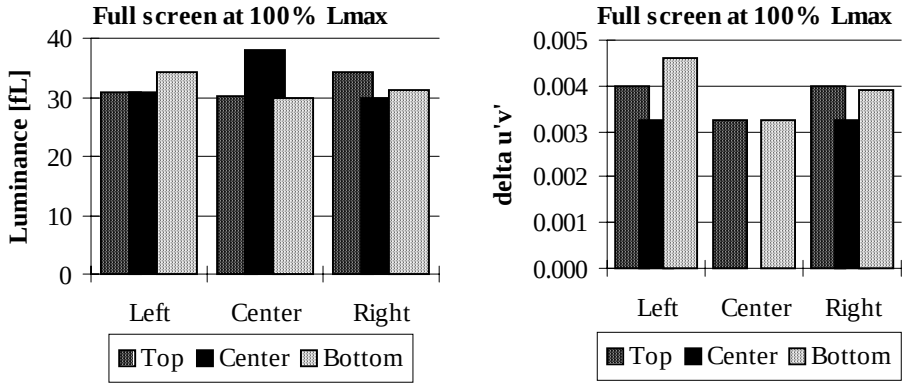


Figure II.3-3. Spatial Uniformity of Luminance Chromaticity. (Delta u'v' of 0.004 is just visible.)

II.4. Halation

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0 Section 4.6, page 48.

For the factory default settings in the monoscopic mode (1600 x 1200 at 37.9fL) and stereoscopic mode (1024 x 1024 at 136 fL), halation was 2.4 % +/- 0.2% on a small black patch surrounded by a large full white area.

Objective: Measure the contribution of halation to contrast degradation. Halation is a phenomenon in which the luminance of a given region of the screen is increased by contributions from surrounding areas caused by light scattering within the phosphor layer and internal reflections inside the glass faceplate. The mechanisms that give rise to halation, and its detailed non-monotonic dependence on the distance along the screen between the source of illumination and the region being measured have been described by E. B. Gindele and S.L. Shaffer. The measurements specified below determine the percentage of light that is piped into the dark areas as a function of the extent of the surrounding light areas.

Equipment:
- Photometer
- Video generator

Test Pattern:

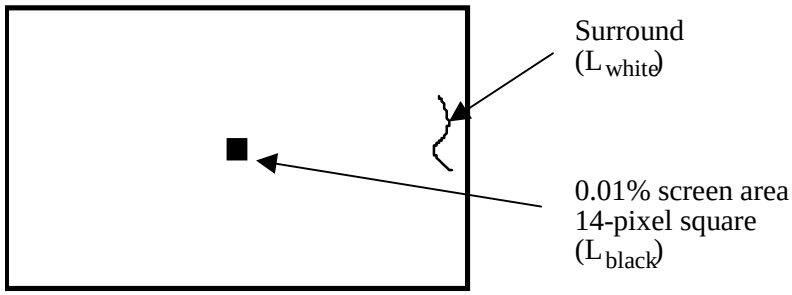


Figure II.4-1 Test pattern for measuring halation in 1600 x 1200 monoscopic mode.

Procedure: Note: The halation measurements require changing the setting of the BRIGHTNESS control and will perturb the values of L_{max} and L_{min} that are established during the initial monitor set-up. The halation measurements should therefore be made either first, before the monitor setup, or last, after all other photometric measurements have been completed.

Determine halation by measuring the luminance of a small square displayed at L_{black} (essentially zero) and at L_{white} when surrounded by a much larger square displayed at L_{white} (approximately 75% L_{max}).

Establish L_{black} by setting the display to cutoff. To set the display to cut-off, display a flat field using video input count level zero, and use a photometer to monitor the luminance at center screen. Vary the BRIGHTNESS control until the CRT beam is visually cut off, and confirm that the corresponding luminance

(L_{stray}) is essentially equal to zero. Fine tune the BRIGHTNESS control such that CRT beam is just on the verge of being cut off. These measurements should be made with a photometer which is sensitive at low light levels (below L_{min} of the display). Make no further adjustments or changes to the BRIGHTNESS control or the photometer measurement field.

Next, decrease the video input level to display a measured full-screen luminance of 75% L_{max} measured at screen center. Record this luminance (L_{white}).

The test target used in the halation measurements is a black (L_{black}) square patch of width equal to 0.01% of the area of addressable screen, the interior square as shown in Figure II.4-1. The interior square patch is enclosed in a white (L_{white}) background encompassing the remaining area of the image. The exterior surround will be displayed at 75% L_{max} using the input count level for L_{white} as determined above. The interior square will be displayed at input digital count level zero.

Care must be taken during the luminance measurement to ensure that the photometer's measurement field is less than one-half the size of the interior square and is accurately positioned not to extend beyond the boundary of the interior square. The photometer should be checked for light scattering or lens flare effects which allow light from the surround to enter the photosensor. A black card with aperture equal to the measurement field (one-half the size of the interior black square) may be used to shield the photometer from the white exterior square while making measurements in the interior black square.

Analysis: Compute the percent halation for each test target configuration. Percent halation is defined as:

$$\% \text{ Halation} = L_{black} \; / \; (L_{white} - L_{black}) \; \times 100$$

Where,

L_{black} = measured luminance of interior square displayed at L_{black} using input count level zero,

L_{white} = measured luminance of interior square displayed at L_{white} using input count level determined to produce a full screen luminance of 75% L_{max} .

Data: Tables II.4-1 and II.4-2 contain measured values of L_{black}, L_{white} and percentage halation. Because no readjustments were made to the factory default settings, Lmin was not set to reset cutoff for the halation measurement. Instead, Lmin was measured and subtracted from both Lblack and Lwhite for the computation of halation.

Table II.4-1 Halation for 1600 x 1200 Monoscopic Mode

	Reported Values	Range for 4% uncertainty
Lmin	0.122 fL ± 4%	0.1175 fL to 0.1273 fL
Lblack	1.037 fL ± 4%	0.996 fL to 1.078 fL
Lwhite	37.54 fL ± 4%	36.04 fL to 39.04 fL
Halation	2.44% ± 0.2%	2.23% to 2.68%

Table II.4-2 Halation for 1024 x 1024 Stereoscopic Mode

	Reported Values	Range for 4% uncertainty
Lmin	0.165 fL ± 4%	0.1584 fL to 0.1716 fL
Lblack	3.287 fL ± 4%	3.156 fL to 3.418 fL
Lwhite	131.9 fL ± 4%	126.6 fL to 137.2 fL
Halation	2.37% ± 0.2%	2.18% to 2.58%

II.5. Color Temperature

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0 Section 5.4, page 22.

The factory default CCT of the measured white point is 11821K and is not specified for monochrome monitors for IEC. The CIE x,y coordinates are 0.251 and 0.307, respectively, and are within the range specified by Siemens.

Objective: Insure measured screen white of a color monitor has a correlated color temperature (CCT) between 6500K and 9300K.

Equipment: Colorimeter

Procedure: Command screen to Lmax. Measure u'v' chromaticity coordinates (CIE 1976).

Data: Coordinates of screen white should be within 0.01 Δ u'v' of the corresponding CIE daylight, which is defined as follows: If the measured screen white has a CCT between 6500 and 9300 K, the corresponding daylight has the same CCT as the screen white. If the measured CCT is greater than 9300 K, the corresponding

daylight is D93. If the measured CCT is less than 6500 K, the corresponding daylight is D65. The following equations were used to compute Δ u'v' values listed in table II.5.1:

1. Compute the correlated color temperature (CCT) associated with (x,y) by the VESA/McCamy formula: CCT = 437 n^3 + 3601 n^2 + 6831 n + 5517, where n = (x-0.3320)/(0.1858 - y). [This is on p. 227 of the FPDM standard]

2. If CCT < 6500, replace CCT by 6500. If CCT > 9300, replace CCT by 9300.

4. Use formulas 5(3.3.4) and 6(3.3.4) in Wyszecki and Stiles (pp.145-146 second edition) to compute the point (xd,yd) associated with CCT.
   - First, define u = 1000/CCT.
   - If CCT < 7000, then xd = -4.6070 u^3 + 2.9678 u^2 + 0.09911 u +
   - 0.244063.
   - If CCT > 7000, then xd = -2.0064 u^3 + 1.9018 u^2 + 0.24748 u +
   - 0.237040.
   - In either case, yd = -3.000 xd^2 + 2.870 xd -0.275.

5. Convert (x,y) and (xd,yd) to u'v' coordinates:
   - (u',v') = (4x,9y)/(3 + 12y - 2x)
   - (u'd,v'd) = (4xd,9yd)/(3 + 12yd - 2xd)

6. Evaluate delta-u'v' between (u,v) and (ud,vd):
   - delta-u'v' = sqrt[(u' - u'd)^2 + (v' - v'd)^2].

7. If delta-u'v' is greater than 0.01, display fails the test. Otherwise it passes the test.

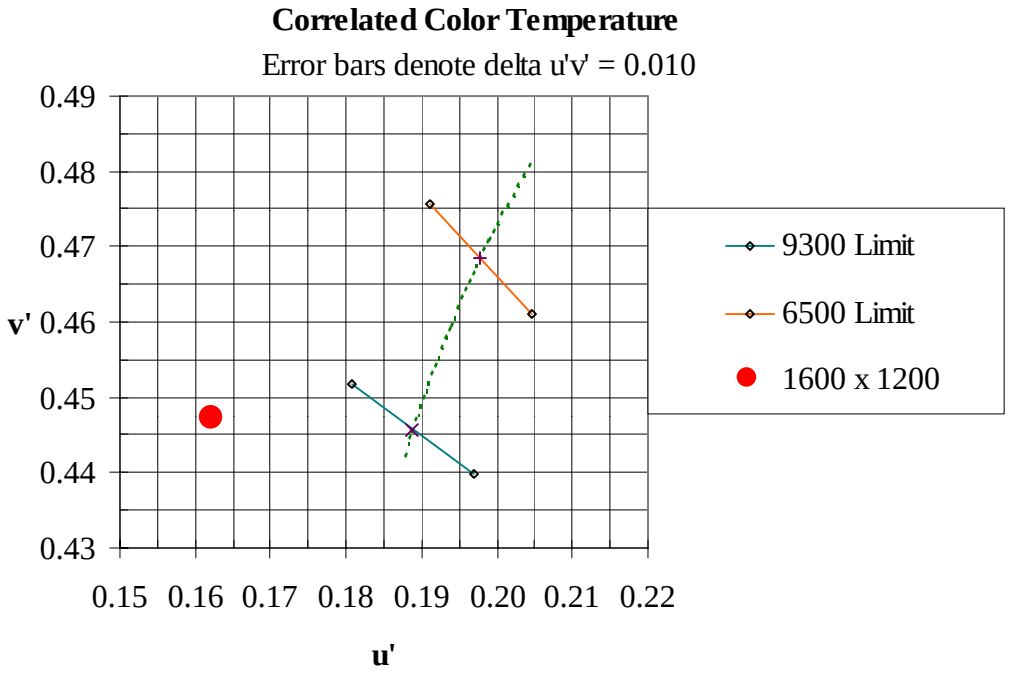


Figure II.5-1 *CCT of the measured white point relative to the Daylight Locus.*

Table II.5-1 Δu'v' Distance between the measured white point and CIE coordinate values from D_{65} to D_{93}.

CIE x CIE y	0.251 0.307
CIE u' CIE v'	0.162 0.447
CCT	11821
delta u'v'	**0.026**

II.6. Bit Depth

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.6, p 6.

For the factory default setting in monoscopic mode, positive increases in luminance were measured for each of the 256 input levels for 8 bits of gray scale. Neither black level clipping nor white level saturation was observed. NIDL measured between 1 and 3 JNDs between each of the 256 gray levels.

Objective: Measure the number of bits of data that can be displayed as a function of the DAC and display software.

Equipment: Photometer

Test targets: Targets are n four inch patches with command levels of all commandable levels; e.g., 256 for 8 bit display. Background is commanded to 0.5* ((0.7 *P)+0.3*n) where P = patch command level, n = number of command levels.

Procedure: Measure patch center for all patches with Lmin and Lmax as defined previously. Count number of monotonically increasing luminance levels. Use the NEMA/DICOM model to define discriminable luminance differences. For color displays, measure white values.

Data: Define bit depth by $\log_2$ (number of discrete luminance levels)

The number of bits of data that can be displayed as a function of the input signal voltage level were verified through measurements of the luminance of white test targets displayed using a Quantum Data 8701 test pattern generator and a Minolta CA-100 colorimeter. Targets are n four-inch patches with command levels of all commandable levels; e.g., 256 for 8 bit display. Background is commanded to 0.5* ((0.7 *P)+0.3*n) where P = patch command level, n = number of command levels. The NEMA/DICOM model was used to define discriminable luminance differences in JNDs.

Figure II.6-1 shows the System Tonal Transfer curve at center screen as a function of input counts. Figure II.6-2 shows the perceptibility of gray level step sizes in Just Noticeable Differences (JNDs) as a function of input counts. The data for each of the 256 levels are listed in Tables II.6-1 and II.6-2.

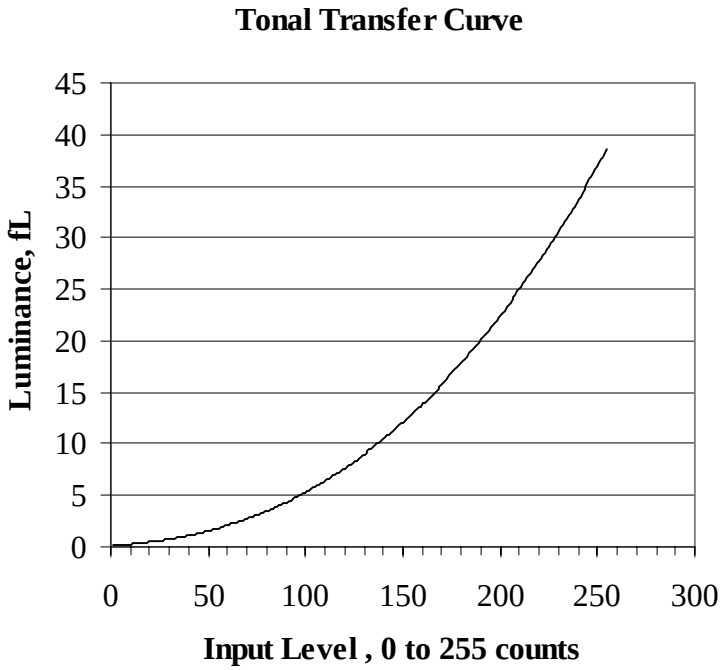


Figure II.6-1. System Tonal Transfer at center screen as a function of input counts.

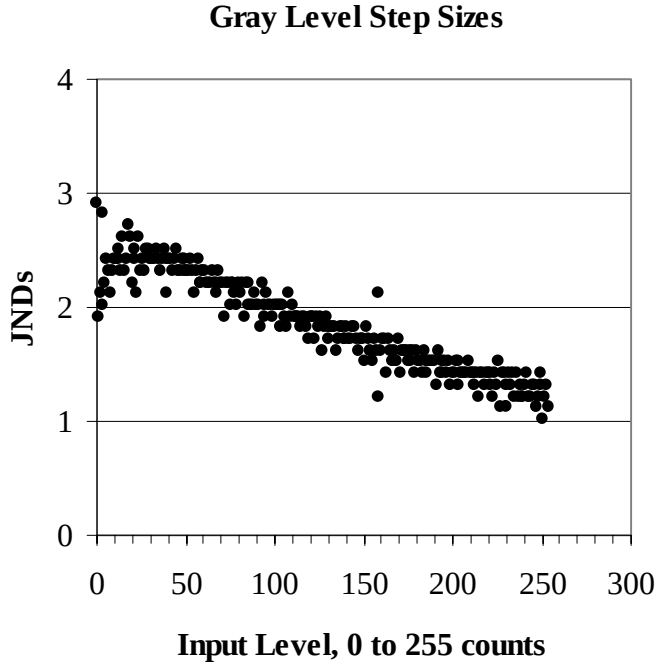


Figure II.6-2. Perceptibility of gray level step sizes in Just Noticeable Differences (JNDs) as a function of input counts.

Table II.6-1. System Tonal Transfer at center screen as a function of input counts 000 to 127.

Background	Target	L, fL	Diff, fL	Diff, JND
38	0	0.152	0	0.0
39	1	0.166	0.014	2.9
39	2	0.176	0.01	1.9
39	3	0.187	0.011	2.1
40	4	0.198	0.011	2.0
40	5	0.214	0.016	2.8
41	6	0.227	0.013	2.2
41	7	0.242	0.015	2.4
41	8	0.257	0.015	2.3
42	9	0.271	0.014	2.1
42	10	0.287	0.016	2.3
42	11	0.304	0.017	2.4
43	12	0.322	0.018	2.4
43	13	0.341	0.019	2.5
43	14	0.36	0.019	2.4
44	15	0.379	0.019	2.3
44	16	0.401	0.022	2.6
44	17	0.421	0.02	2.3
45	18	0.443	0.022	2.4
45	19	0.468	0.025	2.7
45	20	0.493	0.025	2.6
46	21	0.515	0.022	2.2
46	22	0.54	0.025	2.4
46	23	0.567	0.027	2.5
47	24	0.589	0.022	2.1
47	25	0.618	0.029	2.6
48	26	0.645	0.027	2.3
48	27	0.674	0.029	2.4
48	28	0.702	0.028	2.3
49	29	0.733	0.031	2.5
49	30	0.765	0.032	2.5
49	31	0.797	0.032	2.4
50	32	0.829	0.032	2.4
50	33	0.863	0.034	2.4
50	34	0.898	0.035	2.4
51	35	0.935	0.037	2.5
51	36	0.97	0.035	2.4
51	37	1.006	0.036	2.3
52	38	1.045	0.039	2.4
52	39	1.085	0.04	2.5
52	40	1.121	0.036	2.1
53	41	1.162	0.041	2.4
53	42	1.204	0.042	2.4
53	43	1.247	0.043	2.4
54	44	1.289	0.042	2.3
54	45	1.333	0.044	2.4
55	46	1.381	0.048	2.5
55	47	1.427	0.046	2.3
55	48	1.473	0.046	2.3
56	49	1.523	0.05	2.4
56	50	1.572	0.049	2.4
56	51	1.623	0.051	2.3
57	52	1.672	0.049	2.3
57	53	1.725	0.053	2.3
57	54	1.778	0.053	2.4
58	55	1.833	0.055	2.3
58	56	1.883	0.05	2.1
58	57	1.939	0.056	2.3
59	58	1.998	0.059	2.4
59	59	2.055	0.057	2.2
59	60	2.112	0.057	2.2
60	61	2.172	0.06	2.3
60	62	2.234	0.062	2.3
60	63	2.296	0.062	2.2
61	64	2.356	0.06	2.2
61	65	2.42	0.064	2.2
62	66	2.487	0.067	2.3
62	67	2.553	0.066	2.2
62	68	2.617	0.064	2.1
63	69	2.684	0.067	2.2
63	70	2.755	0.071	2.3
63	71	2.827	0.072	2.2
64	72	2.898	0.071	2.2
64	73	2.962	0.064	1.9
64	74	3.035	0.073	2.2
65	75	3.111	0.076	2.2
65	76	3.181	0.07	2.0
65	77	3.26	0.079	2.2
66	78	3.339	0.079	2.2
66	79	3.418	0.079	2.1
66	80	3.494	0.076	2.0
67	81	3.578	0.084	2.2
67	82	3.66	0.082	2.1
67	83	3.745	0.085	2.2
68	84	3.823	0.078	1.9
68	85	3.911	0.088	2.2
69	86	4.001	0.09	2.2
69	87	4.089	0.088	2.0
69	88	4.171	0.082	2.0
70	89	4.261	0.09	2.0
70	90	4.355	0.094	2.1
70	91	4.442	0.087	2.0
71	92	4.533	0.091	2.0
71	93	4.62	0.087	1.8
71	94	4.722	0.102	2.2
72	95	4.816	0.094	1.9
72	96	4.912	0.096	2.0
72	97	5.014	0.102	2.1
73	98	5.116	0.102	2.0
73	99	5.219	0.103	2.0
73	100	5.315	0.096	1.9
74	101	5.423	0.108	2.0
74	102	5.528	0.105	2.0
74	103	5.636	0.108	2.0
75	104	5.735	0.099	1.8
75	105	5.846	0.111	2.0
76	106	5.96	0.114	2.0
76	107	6.071	0.111	1.9
76	108	6.176	0.105	1.8
77	109	6.295	0.119	2.1
77	110	6.412	0.117	1.9
77	111	6.532	0.12	2.0
78	112	6.649	0.117	1.9
78	113	6.768	0.119	1.9
78	114	6.891	0.123	1.9
79	115	7.016	0.125	1.9
79	116	7.132	0.116	1.8
79	117	7.257	0.125	1.9
80	118	7.382	0.125	1.9
80	119	7.51	0.128	1.8
80	120	7.624	0.114	1.7
81	121	7.759	0.135	1.9
81	122	7.892	0.133	1.9
81	123	8.026	0.134	1.9
82	124	8.155	0.129	1.7
82	125	8.289	0.134	1.9
83	126	8.426	0.137	1.8
83	127	8.569	0.143	1.9

Table II.6-2. System Tonal Transfer at center screen as a function of input counts 128 to 255.

Background	Target	L, fL	Diff, fL	Diff, JND
83	128	8.698	0.129	1.6
84	129	8.838	0.14	1.8
84	130	8.981	0.143	1.9
84	131	9.13	0.149	1.8
85	132	9.262	0.132	1.7
85	133	9.414	0.152	1.8
85	134	9.561	0.147	1.8
86	135	9.712	0.151	1.8
86	136	9.845	0.133	1.6
86	137	9.998	0.153	1.7
87	138	10.15	0.152	1.8
87	139	10.31	0.16	1.8
87	140	10.46	0.15	1.7
88	141	10.62	0.16	1.7
88	142	10.78	0.16	1.8
88	143	10.94	0.16	1.7
89	144	11.1	0.16	1.7
89	145	11.27	0.17	1.8
90	146	11.44	0.17	1.8
90	147	11.61	0.17	1.7
90	148	11.77	0.16	1.6
91	149	11.94	0.17	1.7
91	150	12.11	0.17	1.7
91	151	12.28	0.17	1.7
92	152	12.44	0.16	1.5
92	153	12.62	0.18	1.8
92	154	12.8	0.18	1.7
93	155	12.98	0.18	1.6
93	156	13.14	0.16	1.5
93	157	13.32	0.18	1.7
94	158	13.5	0.18	1.6
94	159	13.638	0.138	1.2
94	160	13.87	0.232	2.1
95	161	14.06	0.19	1.6
95	162	14.25	0.19	1.7
95	163	14.45	0.2	1.7
96	164	14.62	0.17	1.4
96	165	14.82	0.2	1.7
97	166	15.02	0.2	1.6
97	167	15.2	0.18	1.5
97	168	15.38	0.18	1.5
98	169	15.58	0.2	1.6
98	170	15.78	0.2	1.5
98	171	15.99	0.21	1.7
99	172	16.18	0.19	1.4
99	173	16.38	0.2	1.6
99	174	16.6	0.22	1.6
100	175	16.81	0.21	1.6
100	176	17.01	0.2	1.5
100	177	17.22	0.21	1.5
101	178	17.44	0.22	1.6
101	179	17.66	0.22	1.6
101	180	17.86	0.2	1.4
102	181	18.08	0.22	1.6
102	182	18.3	0.22	1.5
102	183	18.52	0.22	1.5
103	184	18.72	0.2	1.4
103	185	18.95	0.23	1.6
104	186	19.17	0.22	1.4
104	187	19.4	0.23	1.5
104	188	19.62	0.22	1.5
105	189	19.85	0.23	1.5
105	190	20.08	0.23	1.5
105	191	20.32	0.24	1.5
106	192	20.53	0.21	1.3
106	193	20.78	0.25	1.6
106	194	21.01	0.23	1.4
107	195	21.26	0.25	1.5
107	196	21.49	0.23	1.4
107	197	21.74	0.25	1.5
108	198	21.98	0.24	1.4
108	199	22.23	0.25	1.5
108	200	22.45	0.22	1.3
109	201	22.7	0.25	1.4
109	202	22.95	0.25	1.4
109	203	23.21	0.26	1.5
110	204	23.45	0.24	1.3
110	205	23.71	0.26	1.5
111	206	23.96	0.25	1.4
111	207	24.23	0.27	1.4
111	208	24.48	0.25	1.4
112	209	24.74	0.26	1.4
112	210	25.03	0.29	1.5
112	211	25.3	0.27	1.4
113	212	25.56	0.26	1.4
113	213	25.83	0.27	1.4
113	214	26.1	0.27	1.3
114	215	26.37	0.27	1.4
114	216	26.62	0.25	1.2
114	217	26.89	0.27	1.4
115	218	27.17	0.28	1.4
115	219	27.45	0.28	1.3
115	220	27.74	0.29	1.4
116	221	28.02	0.28	1.4
116	222	28.3	0.28	1.3
116	223	28.6	0.3	1.4
117	224	28.86	0.26	1.2
117	225	29.15	0.29	1.4
118	226	29.45	0.3	1.3
118	227	29.77	0.32	1.5
118	228	30.03	0.26	1.1
119	229	30.33	0.3	1.4
119	230	30.65	0.32	1.4
119	231	30.94	0.29	1.3
120	232	31.2	0.26	1.1
120	233	31.52	0.32	1.4
120	234	31.84	0.32	1.3
121	235	32.16	0.32	1.4
121	236	32.46	0.3	1.2
121	237	32.78	0.32	1.4
122	238	33.07	0.29	1.2
122	239	33.39	0.32	1.3
122	240	33.68	0.29	1.2
123	241	34	0.32	1.2
123	242	34.32	0.32	1.3
123	243	34.67	0.35	1.4
124	244	34.97	0.3	1.2
124	245	35.29	0.32	1.2
125	246	35.61	0.32	1.3
125	247	35.96	0.35	1.3
125	248	36.25	0.29	1.1
126	249	36.57	0.32	1.2
126	250	36.92	0.35	1.3
126	251	37.3	0.38	1.4
127	252	37.56	0.26	1.0
127	253	37.91	0.35	1.2
127	254	38.26	0.35	1.3
128	255	38.58	0.32	1.1

II.8. Luminance Step Response

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.8, p 7.

No video artifacts were observed factory default and user adjusted settings for Lmax luminance values ranging from 35 fL to 250 fL at the CRT.

Objective: Determine the presence of artifacts caused by undershoot or overshoot.

Equipment: Test targets, SMPTE Test Pattern RP-133-1991, 2-D CCD array

Procedure: Display a center box 15% of screen size at input count levels corresponding to 25%, 50%, 75%, and 100% of Lmax with a surround of count level 0. Repeat using SMPTE Test pattern

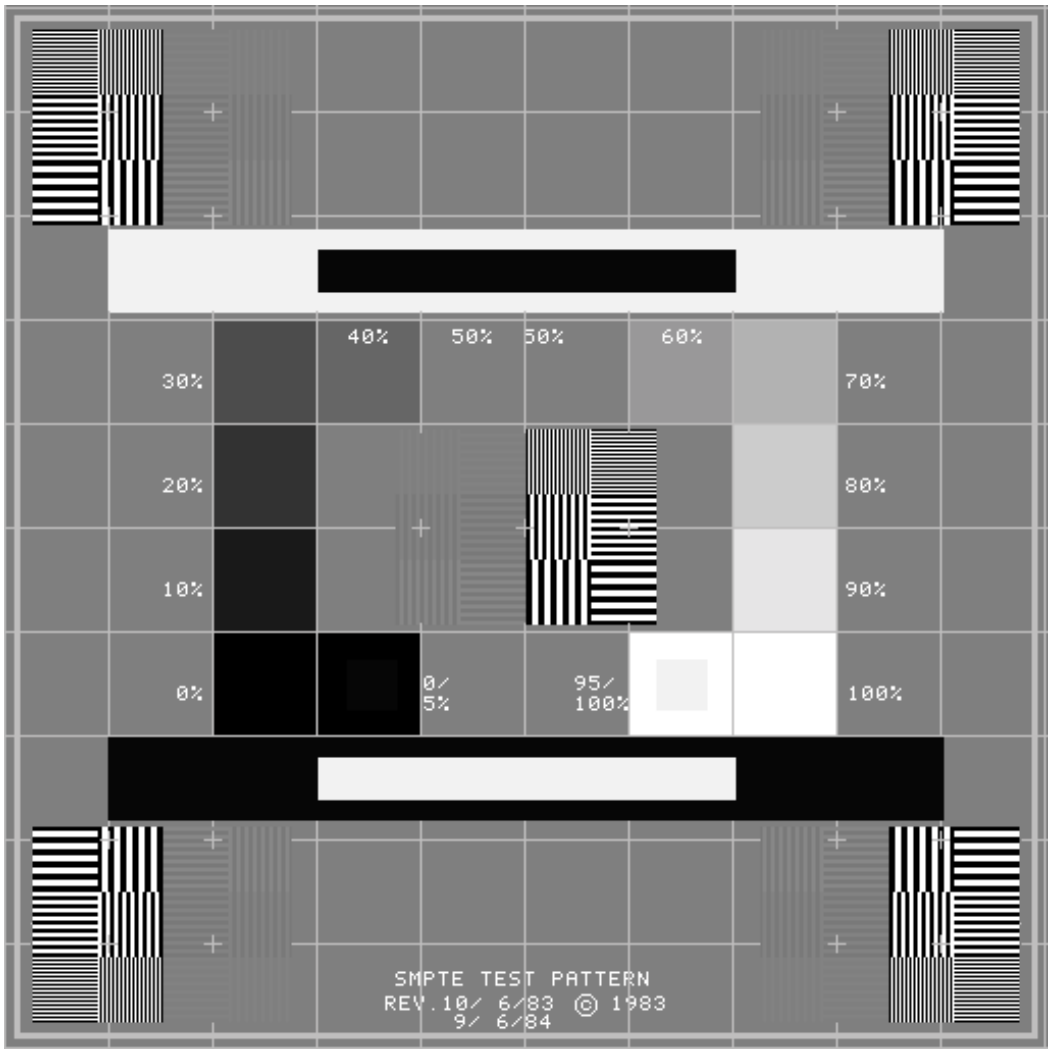


Figure II.8-1. SMPTE Test Pattern.

Data: Define pass by absence of noticeable ringing, undershoot, overshoot, or streaking.

The test pattern shown in Figure II.8-1 was used in the visual evaluation of the monitor. This test pattern is defined in SMPTE Recommended Practice RP-133-1986 published by the Society of Motion Picture and Television Engineers (SMPTE) for medical imaging applications. Referring to the large white-in-black and black-in-white horizontal bars contained in the test pattern, RP133-1986, paragraph 2.7 states " These areas of maximum contrast facilitate detection of mid-band streaking (poor low-frequency response), video amplifier ringing or overshoot, deflection interference, and halo." None of these artifacts was observed in the Precision Imaging Corporation 21si monitor, signifying good electrical performance of the video circuits.

II.9. Addressability

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0, Section 6.1, page 67.

This monitor properly displayed all addressed pixels for the following tested factory default formats (HxV): 1600 x 1200x 75 Hz and 1024 x 1024 x 121 Hz.

Objective: Define the number of addressable pixels in the horizontal and vertical dimension; confirm that stated number of pixels is displayed.

Equipment: Programmable video signal generator.
Test pattern with pixels lit on first and last addressable rows and columns and on two diagonal lines beginning at upper left and lower right; H & V grill patterns 1-on/1-off.

Procedure: The number of addressed pixels were programmed into the Quantum Data 8701 test pattern generator for 72 Hz minimum for monoscopic mode and 120 Hz minimum for stereoscopic mode, where possible. All perimeter lines were confirmed to be visible, with no irregular jaggies on diagonals and, for monochrome monitors, no strongly visible moiré on grilles.

Data: If tests passed, number of pixels in horizontal and vertical dimension. If test fails, addressability unknown.

Table II.9-1 Addressabilities Tested

Monoscopic Mode	Stereo Mode
1600 x 1200	1024 x 1024

II.10. Pixel Aspect Ratio

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.10, p 8.

Pixel aspect ratio is within 0.1% for the factory default 1600 x 1200 monoscopic mode.

Objective: Characterize aspect ratio of pixels.

Equipment: Test target, measuring tape with at least 1/16th inch increments

Procedure: Display box of 400 x 400 pixels at input count corresponding to 50% Lmax and background of 0. Measure horizontal and vertical dimension.

Alternatively, divide number of addressable pixels by the total image size to obtain nominal pixel spacings in horizontal and vertical directions.

Data: Define pass if H= V± 6% for pixel density <100 ppi and ± 10% for pixel density > 100 ppi.

Table II.10-1 Pixel Aspect Ratio

Averages	Monoscopic Mode
Addressability (H x V)	1600 x 1200 Full Screen
H x V Image Size (inches)	15.595 x 11.683
H x V Pixel Spacing (mils)	9.75 x 9.74 mils
H x V Pixel Aspect Ratio	H = V + 0.1%

II.11. Screen Size (Viewable Active Image)

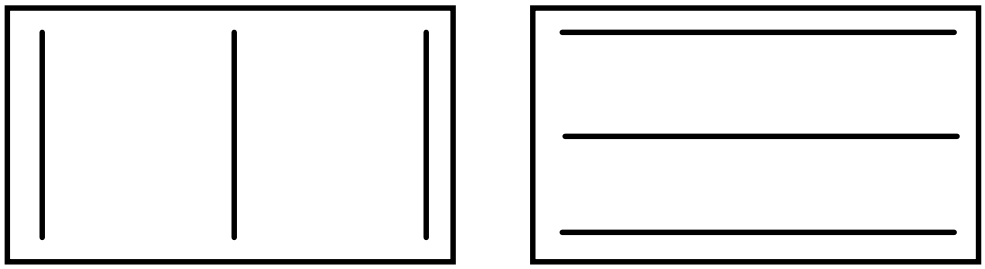
Reference: VESA Flat Panel Display Measurements Standard, Version 1.0, May 15, 1998, Section 501-1.

Image size as tested was 19.485 inches in diagonal for the factory default 1600 x 1200 monoscopic mode.

Objective: Measure beam position on the CRT display to quantify width and height of active image size visible by the user (excludes any overscanned portion of an image).

Equipment:
- Video generator
- Spatially calibrated CCD or photodiode array optic module
- Calibrated X-Y translation stage

Test Pattern: Use the three-line grille patterns in Figure II.11-1 for vertical and horizontal lines each 1-pixel wide. Lines in test pattern are displayed at 100% L_{max} must be positioned along the top, bottom, and side edges of the addressable screen, as well as along both the vertical and horizontal centerlines (major and minor axes).



1-pixel-wide lines displayed at 100% L_{max}

Figure II.11-1 Three-line grille test patterns.

Procedure: Use diode optic module to locate center of line profiles in conjunction with calibrated X-Y translation to measure screen x, y coordinates of lines at the ends of the major and minor axes.

Data: Compute the image width defined as the average length of the horizontal lines along the top, bottom and major axis of the screen. Similarly, compute the image height defined as the average length of the vertical lines along the left side, right side, and minor axis of the screen. Compute the diagonal screen size as the square root of the sum of the squares of the width and height.

Table II.11-1. Image Size

	Monoscopic Mode
Addressability (H x V)	1600 x 1200
H x V Image Size (inches) Diagonal Image Size (inches)	15.595 x 11.683 19.485

II.12. Contrast Modulation

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0, Section 5.2, page 57.

For the factory default 1600 x 1200 monoscopic mode, contrast modulation (Cm) for 1-on/1-off grille patterns displayed at 50% Lmax (Lmax= 37.9 fL) exceeded Cm = 74% in Zone A, and exceeded Cm = 65% in Zone B. Contrast modulation for the raster in a full white screen is 51% and appeared more prominent compared to the 21103 monitor. These values for Cm far exceed the IEC requirements.

Objective: Quantify contrast modulation as a function of screen position.

Equipment:
- Video generator
- Spatially calibrated CCD or photodiode array optic module
- Photometer with linearized response

Procedure: The maximum video modulation frequency for each 1600 x 1200 format was examined using horizontal and vertical grille test patterns consisting of alternating lines with 1 pixel on, 1 pixel off. Contrast modulation was measured in both horizontal and vertical directions at screen center and at eight peripheral screen positions. The measurements should be along the horizontal and vertical axes and along the diagonal from these axes. Use edge measurements no more than 10% of screen size in from border of active screen. The input signal level was set so that 1-line-on/1-line-off horizontal grille patterns produced a screen area-luminance of 25% of maximum level, Lmax.

Zone A is defined as a 24 degree subtense circle from a viewing distance of 18 inches (7.6 inch circle). Zone B is the remainder of the display. Use edge measurements no more than 10% of screen size in from border of active screen area to define Cm for Zone B (remaining area outside center circle). Determine Cm at eight points on circumference of circle by interpolating between center and display edge measurements to define Cm for Zone A. If measurements exceed the threshold, do not make any more measurements. If one or more measurements fail the threshold, make eight additional measurements at the edge (but wholly within) the defined circle.

Data: Values of vertical and horizontal Cm for Zone A and Zone B are given in Table II.12-1. The contrast modulation, Cm, is reported (the defining equation is given below) for the 1-on/1-off grille patterns. The modulation is equal to or greater than 51% in Zone A, and is equal to or greater than 35% in Zone B.

$$C_m = \frac{L_{peak} - L_{valley}}{L_{peak} + L_{valley}}$$

Table II.12-1. Contrast Modulation
Corrected for lens flare and Zone Interpolation

Zone A 7.6-inch diameter circle for 24-degree subtense at 18-inch viewing distance

	Left		Minor						Right	
	H-grille	V-grille	H-grille	V-grille	H-grille	V-grille	H-grille	V-grille	H-grille	V-grille
Top	80%	74%			89%	77%			81%	65%
			86%	77%	90%	78%	87%	74%		
Major	91%	78%	91%	79%	90%	79%	94%	75%	97%	71%
			91%	75%	90%	79%	88%	74%		
Bottom	91%	68%			89%	79%			84%	67%

Zone A 9.63-inch diameter circle for 40% area

	Left		Minor						Right	
	H-grille	V-grille	H-grille	V-grille	H-grille	V-grille	H-grille	V-grille	H-grille	V-grille
Top	80%	74%			89%	77%			81%	65%
			89%	80%	91%	79%	90%	76%		
Major	91%	78%	94%	81%	98%	86%	97%	77%	97%	71%
			95%	77%	91%	81%	91%	77%		
Bottom	91%	68%			89%	79%			84%	67%

II.13. Pixel Density

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.13, p 9.

FACTORY DEFAULT: Pixel density was 103 H x 103 V ppi for the 1600 x 1200-line addressable monoscopic format. Pixel density was 84.9 H x 89.9 V ppi for the 1024 x 1024-line addressable stereoscopic format.

Objective: Characterize density of image pixels

Equipment: Measuring tape with at least 1/16 inch increments

Procedure: Measure H&V dimension of active image window and divide by vertical and horizontal addressability

Data: Define horizontal and vertical pixel density in terms of pixels per inch

Table II.13-1. Pixel-Density

	Monoscopic Mode	Stereoscopic Mode
Addressability (H x V)	1600 x 1200	1024 x 1024
H x V Image Size (inches)	15.595 x 11.683	12.068 x 11.389
H x V Pixel Density, ppi	103 x 103	84.9 x 89.9

II.14. Moiré

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.14, p 9.

Not applicable to monochrome monitors.

II.15. Straightness

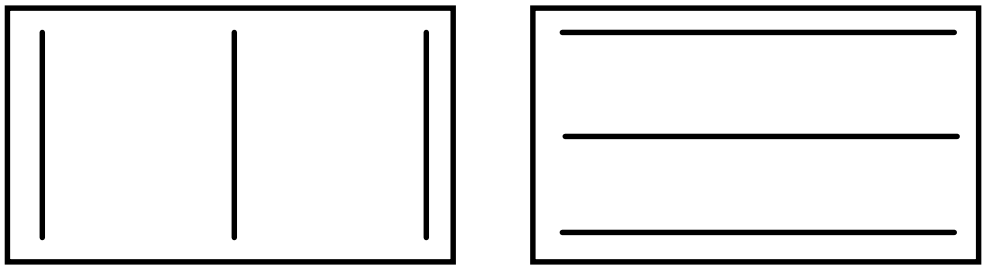
Reference: Monochrome CRT Monitor Performance, Draft Version 2.0, Section 6.1 Waviness, page 67.

For the default 1600 x 1200 monoscopic mode, waviness, a measure of straightness, did not exceed 0.45% of the image width or height.

Objective: Measure beam position on the CRT display to quantify effects of waviness which causes nonlinearities within small areas of the display distorting nominally straight features in images, characters, and symbols.

Equipment:
- Video generator
- Spatially calibrated CCD or photodiode array optic module
- Calibrated X-Y translation stage

Test Pattern: Use the three-line grille patterns in Figure II.15-1 for vertical and horizontal lines each 1-pixel wide. Lines in test pattern are displayed at 100% L_{max} must be positioned along the top, bottom, and side edges of the addressable screen, as well as along both the vertical and horizontal centerlines (major and minor axes).



1-pixel-wide lines displayed at 100% L_{max}

Figure II.15-1 Three-line grille test patterns.

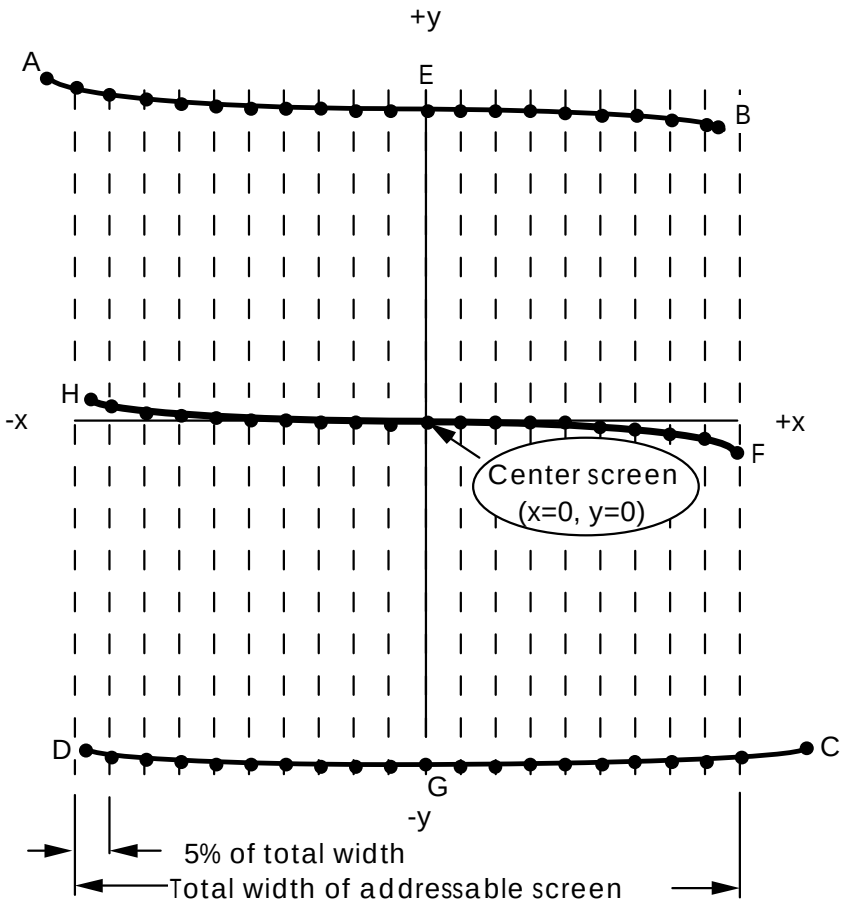


Figure II.15-2 Measurement locations for waviness along horizontal lines. Points A, B, C, D are extreme corner points of addressable screen. Points E, F, G, H are the endpoints of the axes.

Procedure: Use diode optic module to locate center of line profiles in conjunction with calibrated X-Y translation to measure screen x, y coordinates along the length of a nominally straight line. Measure x, y coordinates at 5% addressable screen intervals along the line. Position vertical lines in video to land at each of three (3) horizontal screen locations for determining waviness in the horizontal direction. Similarly, position horizontal lines in video to land at each of three (3) vertical screen locations for determining waviness in the vertical direction.

Data: Tabulate x, y positions at 5% addressable screen increments along nominally straight lines at top and bottom, major and minor axes, and left and right sides of the screen as shown in Table II.15-1. Figure II.15-3 shows the results in graphical form.

Table II.15-1. Straightness

Tabulated x, y positions at 5% addressable screen increments along nominally straight lines.

Top		Bottom		Major		Minor		Left Side		Right Side	
x	y	x	y	x	y	x	y	x	y	x	y
-7895	5829	-7808	-5867	-7852	-6	19	5795	-7895	5829	7771	5833
-7200	5824	-7200	-5874	-7200	-11	20	5400	-7892	5400	7770	5400
-6400	5819	-6400	-5869	-6400	-10	18	4800	-7892	4800	7768	4800
-5600	5813	-5600	-5863	-5600	-9	16	4200	-7892	4200	7767	4200
-4800	5808	-4800	-5854	-4800	-7	13	3600	-7892	3600	7763	3600
-4000	5802	-4000	-5846	-4000	-5	10	3000	-7890	3000	7760	3000
-3200	5799	-3200	-5840	-3200	-4	8	2400	-7884	2400	7754	2400
-2400	5796	-2400	-5836	-2400	-2	5	1800	-7875	1800	7745	1800
-1600	5795	-1600	-5834	-1600	-1	3	1200	-7866	1200	7736	1200
-800	5794	-800	-5833	-800	0	1	600	-7858	600	7730	600
0	5795	0	-5833	0	0	0	0	-7852	0	7728	0
800	5799	800	-5837	800	1	-2	-600	-7850	-600	7727	-600
1600	5805	1600	-5843	1600	2	-5	-1200	-7852	-1200	7728	-1200
2400	5812	2400	-5850	2400	2	-8	-1800	-7854	-1800	7729	-1800
3200	5820	3200	-5857	3200	2	-10	-2400	-7856	-2400	7730	-2400
4000	5826	4000	-5865	4000	2	-10	-3000	-7855	-3000	7730	-3000
4800	5833	4800	-5873	4800	0	-9	-3600	-7848	-3600	7730	-3600
5600	5838	5600	-5880	5600	-3	-8	-4200	-7838	-4200	7728	-4200
6400	5842	6400	-5887	6400	-6	-6	-4800	-7828	-4800	7727	-4800
7200	5842	7200	-5891	7200	-11	-1	-5400	-7816	-5400	7728	-5400
7767	5831	7735	-5889	7727	-17	2	-5833	-7808	-5867	7734	-5891

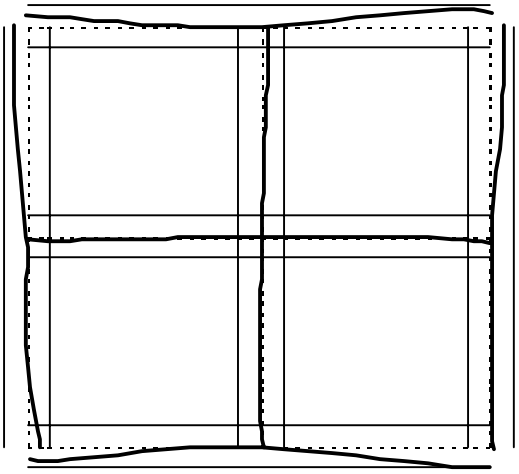


Figure II.15-3 Waviness of Siemens SMM 21105 L (STEREO) Monitor in 1600 x 1200 mode. Departures from straight lines are exaggerated on a 10X scale. Error bars are +/- 0.5% of total screen size.

II.16. Refresh Rate

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.16, p 9.

For the Siemens factory default settings, the vertical refresh rate for the1600 x 1200 monoscopic format was set to 75 Hz, and was set to 121 Hz for the 1024 x 1024 stereoscopic format.

Objective: Define vertical and horizontal refresh rates.

Equipment: Programmable video signal generator.

Procedure: The refresh rates were programmed into the Quantum Data 8701 test pattern generator for 72 Hz minimum for monoscopic mode and 120 Hz minimum for stereoscopic mode, where possible.

Data: Report refresh rates in Hz.

Table II.16-1 Refresh Rates as Tested

	Monoscopic Mode	Stereoscopic Mode
Addressability	1600 x 1200	1024 x 1024
Vertical Scan	75 Hz	121. Hz
Horizontal Scan	93.750 kHz	132.56 kHz

II.17. Extinction Ratio

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.17, p10.

FACTORY DEFAULT: Using the factory default settings, the monitor did not have sufficient luminance (Lmax = 17.1fL) at the analyst's eye point to pass the IEC requirement of 30fL for stereoscopic mode through the ZScreen and passive glasses. Stereo extinction ratio for the ZScreen and passive polarized glasses averaged 33.1 to 1 (41.1 left, 25.4 right) at screen center. Luminance of white varied by up to 18.8% across the screen. Chromaticity variations of white were 0.008 delta u'v' units or less. Stereo extinction ratio for the active polarized LC shutter glasses averaged 83.7 to 1 (86.7 left, 80.7 right) at screen center. The extinction ratio for the ZScreen/passive glasses, and for the active shutter glasses exceeded the IEC minimum value of 20:1.

USER ADJUSTED: The Siemens 21105L monitor passes the IEC requirements for stereoscopic mode only when user adjustments are made to increase the luminance beyond the Siemens factory preset Lmax to achieve IEC required 30 fL threshold at the analyst's eye. With Lmax set to 250 fL at the CRT screen to achieve 34 fL at the analyst's eye viewpoint, stereo extinction ratio for the ZScreen and passive polarized glasses averaged 31.0 to 1 (38.4 left, 23.6 right) at screen center. Luminance of white varied by up to 18.6% across the screen.

Objective: Measure stereo extinction ratio.

Equipment: Two “stereo” pairs with full addressability. One pair has left center at command level of 255 (or Cmax) and right center at 0. The other pair has right center at command level of 255 (or Cmax) and left center at 0.

Stereoscopic-mode measurements were made using a commercially available Nuvision 19-inch LCD shutter with passive polarized eyeglasses, with a StereoGraphics ZScreen and passive glasses, or with active StereoGraphics shutter glasses.

Procedure: Calibrate monitor to 0.1 fL Lmin and 35 fL Lmax (no ambient). Measure ratio of Lmax to Lmin on both left and right side images through the stereo system.

Data: Extinction ratio (left) = L (left,on, white/black)/left,off, black/white)

L(left,on, white/black) ~ trans(left,on)*trans(stereo)*L(max)*Duty(left)
+ trans(left,off)*trans (stereo)*L(min)*Duty (right)
Use left,off/right,on to perform this measurement

Extinction ratio (right) = L (right,on,white/black)/right,off, black/white)

L(right,on, white/black) ~ trans(right,on)*trans(stereo)*L(max)*Duty(right)
+ trans(right,off)*trans (stereo)*L(min)*Duty (left)
Use left,on/right,off to perform this measurement

Stereo extinction ratio is average of left and right ratios defined above.

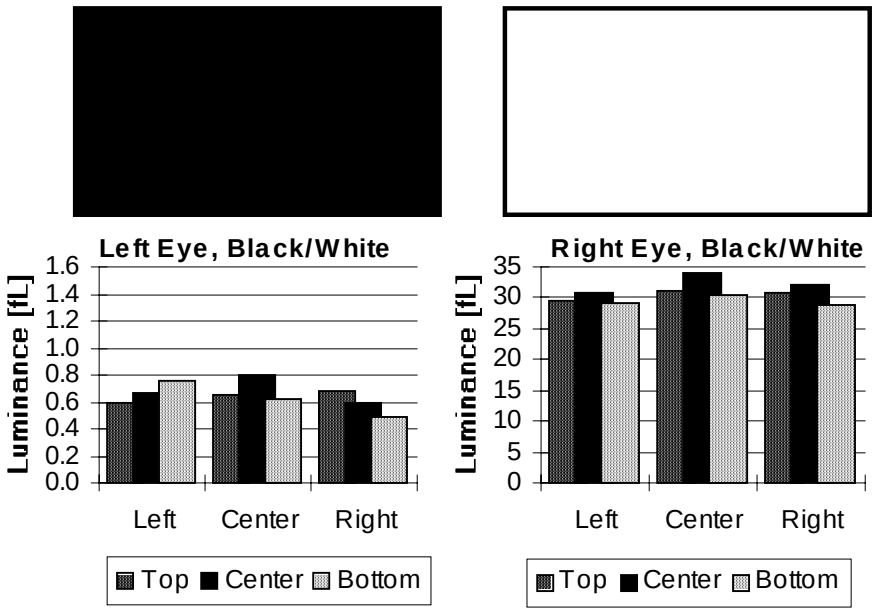


Figure II.17-1. Spatial Uniformity of luminance for **factory default settings** in stereo mode when displaying black to the left eye while displaying white to the right eye for the Stereographics ZScreen and its passive polarized glasses.

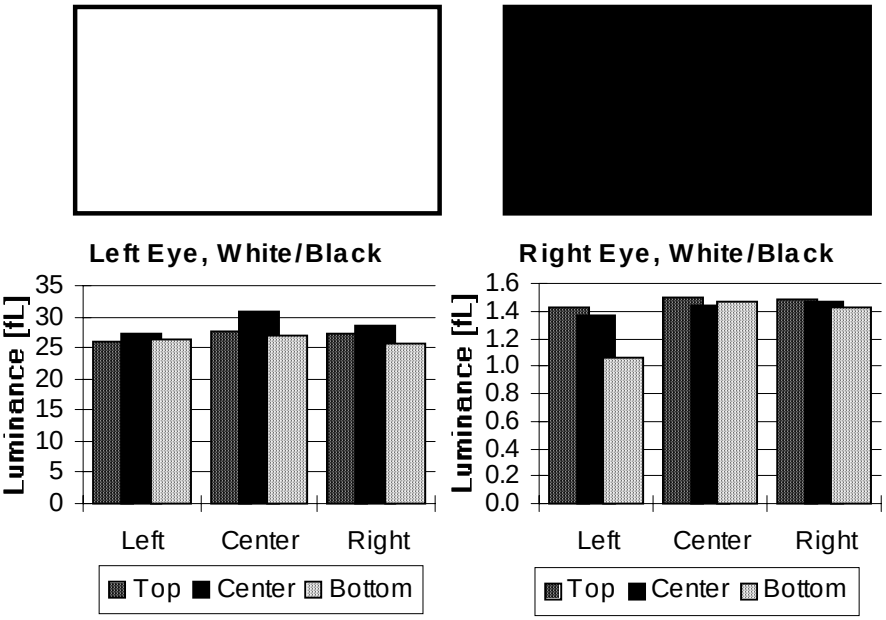


Figure II.17-2. Spatial Uniformity of luminance in for **factory default settings** stereo mode when displaying white to the left eye while displaying black to the right eye for the Stereographics ZScreen and its passive polarized glasses.

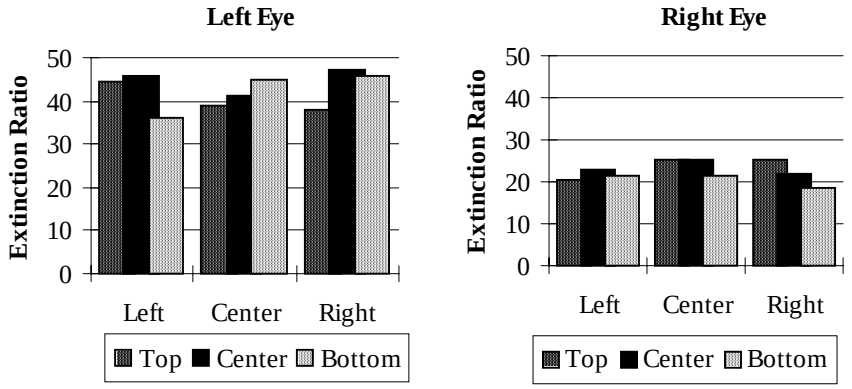


Figure II.17-3. Spatial Uniformity of extinction ratio for **factory default settings** in stereo mode for the Stereographics ZScreen and its passive polarized glasses.

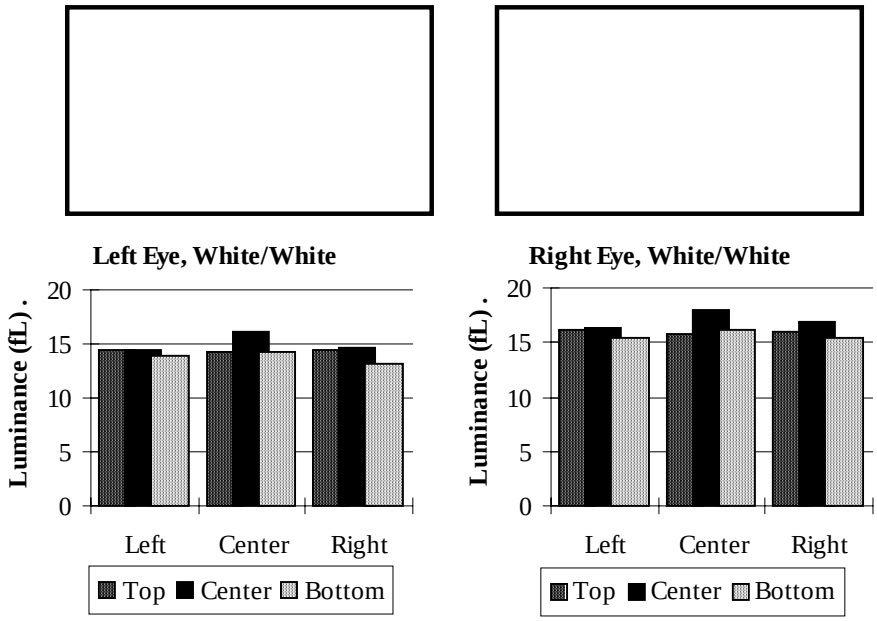


Figure II.17-4 Spatial Uniformity of chromaticity of white for **factory default settings** in stereo mode for the Stereographics ZScreen and its passive polarized glasses.

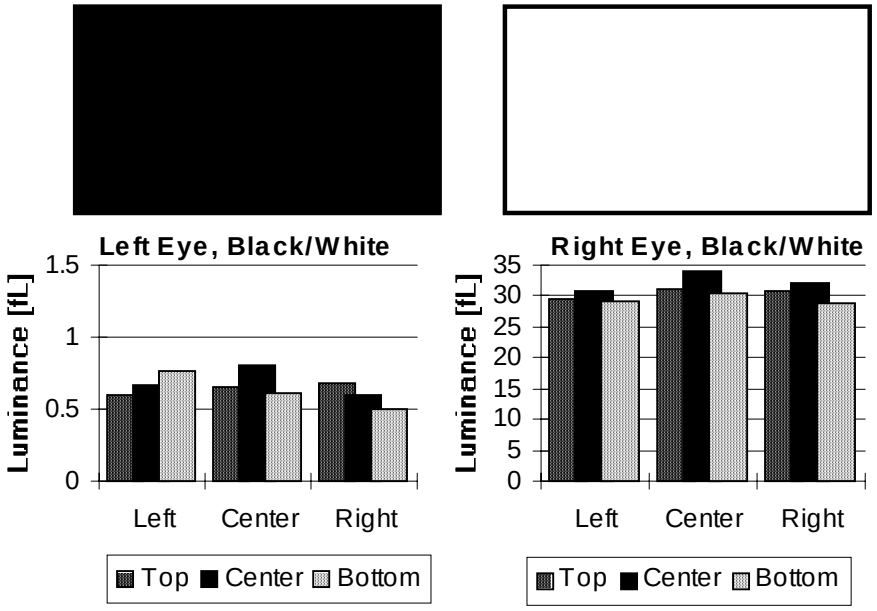


Figure II.17-5. Spatial Uniformity of luminance with **Lmin and Lmax user adjusted to meet IEC requirements using SMfit** in stereo mode when displaying black to the left eye while displaying white to the right eye for the Stereographics ZScreen and its passive polarized glasses.

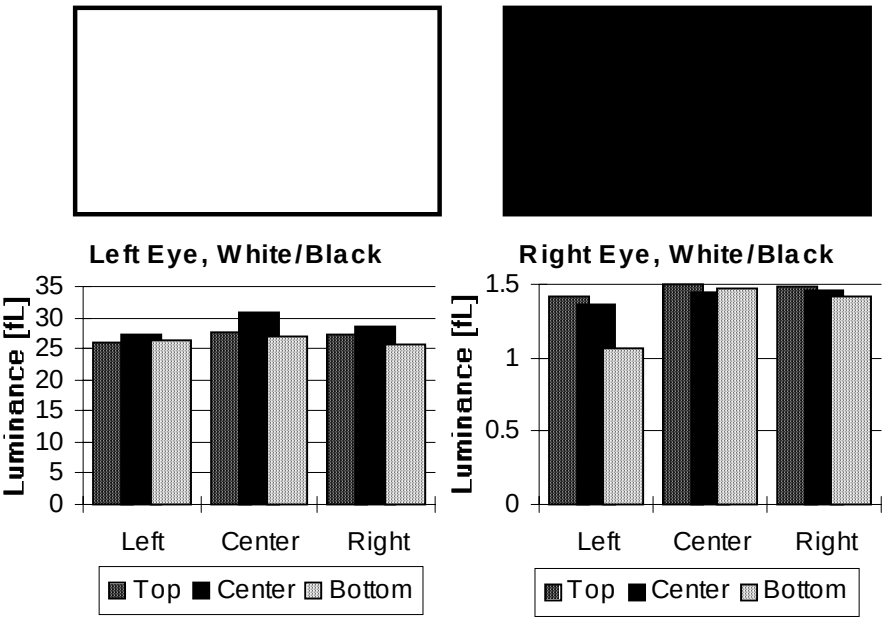


Figure II.17-6. Spatial Uniformity of luminance in for **Lmin and Lmax user adjusted to meet IEC requirements using SMfit** in stereo mode when displaying white to the left eye while displaying black to the right eye for the Stereographics ZScreen and its passive polarized glasses.

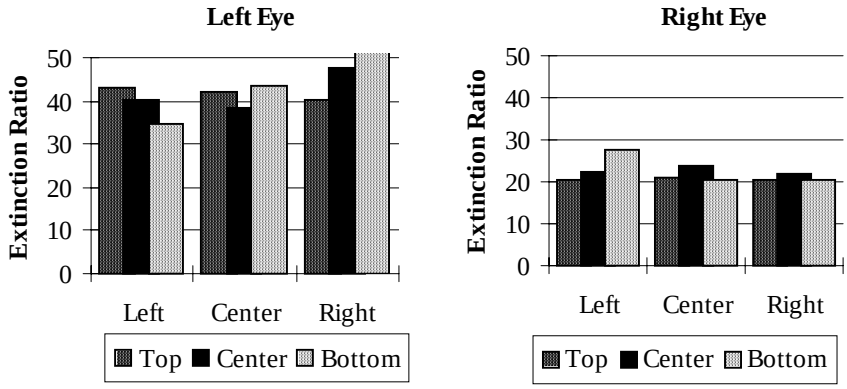


Fig.II.17-7. Spatial Uniformity of extinction ratio for **Lmin and Lmax user adjusted to meet IEC requirements using SMfit** in stereo mode for the Stereographics ZScreen and its passive polarized glasses.

II.18. Linearity

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0, Section 6.2, page 73.

FACTORY DEFAULT: The maximum nonlinearity of scan for the default factory setting was -2.34% of full screen and did not meet the IEC requirement of 1.0% or less.

USER ADJUSTED: The Horizontal S-Correction adjustment in SMfit was used to successfully reduce the linearity to -0.7% in order to pass the IEC requirement.

Objective: Measure the relation between the actual position of a pixel on the screen and the commanded position to quantify effects of raster nonlinearity. Nonlinearity of scan degrades the preservation of scale in images across the display.

Equipment:
- Video generator
- Spatially calibrated CCD or photodiode array optic module
- Calibrated X-Y translation stage

Test Pattern: Use grille patterns of single-pixel horizontal lines and single-pixel vertical lines displayed at 100% L_{max}. Lines are equally spaced in addressable pixels. Spacing must be constant and equal to approximately 5% screen width and height to the nearest addressable pixel as shown in Figure II.18-1.

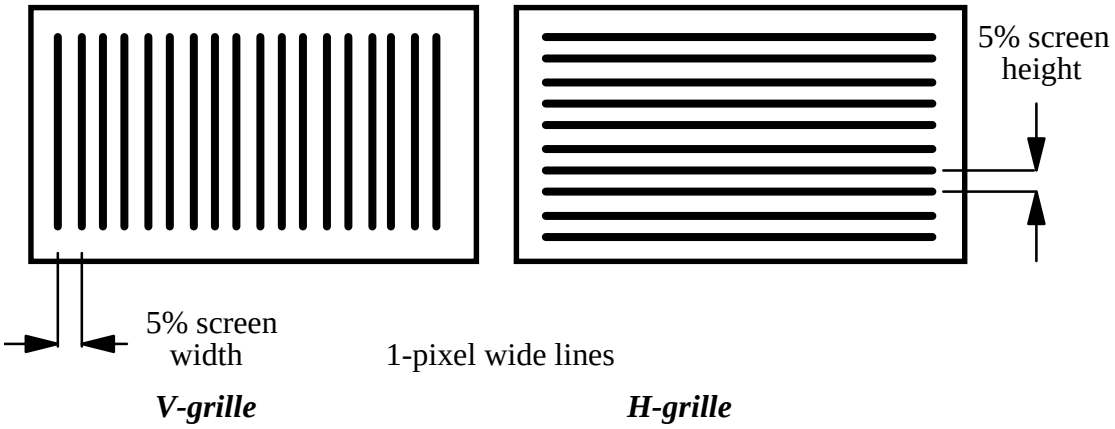


Figure II.18-1. Grille patterns for measuring linearity

Procedure: The linearity of the raster scan is determined by measuring the positions of lines on the screen. Vertical lines are measured for the horizontal scan, and horizontal lines for the vertical scan. Lines are commanded to 100% Lmax and are equally spaced in the time domain by pixel indexing on the video test pattern. Use optic module to locate center of line profiles in conjunction with x, y-translation stage to measure screen x, y coordinates of points where video pattern vertical lines intersect horizontal centerline of screen and where horizontal lines intersect vertical centerline of the CRT screen as shown in Figure II.18-2.

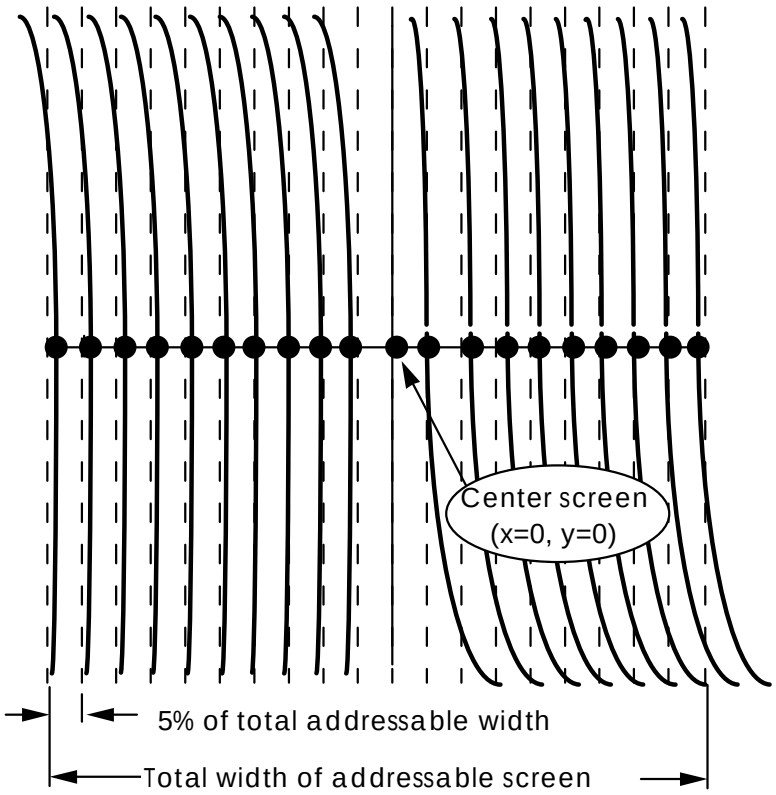


Figure II.18-2. Measurement locations for horizontal linearity along the major axis of the display. Equal pixel spacings between vertical lines in the grille pattern are indicated by the dotted lines. The number of pixels per space is nominally equivalent to 5% of the addressable screen size.

Data: Tabulate x, y positions of equally spaced lines (nominally 5% addressable screen apart) along major (horizontal centerline) and minor (vertical centerline) axes of the raster. If both scans were truly linear, the differences in the positions of adjacent lines would be a constant. The departures of these differences from constancy impacts the absolute position of each pixel on the screen and is, then, the nonlinearity. The degree of nonlinearity may be different between left and right and between top and bottom. The maximum horizontal and vertical nonlinearities (referred to full screen size) are listed in table II.18-1. The complete measured data are listed in table II.18-2 and shown graphically in Figure II.18-3.

Table II.18-1. Maximum Horizontal and Vertical Nonlinearities

Set Up Condition	Format	Left Side	Right Side	Top	Bottom
Factory Default	1600 x 1200	-2.34%	1.52%	-0.24%	-0.11%
User Adjusted using SMfit	1600 x 1200	-0.59%	-0.70%	-0.24%	-0.11%

Table II.18-2. Horizontal and Vertical Nonlinearity Data for the Factory Default Setting

Factory Default Setting Failed IEC

Vertical Lines x-Position (mils)		Horizontal lines y-Position (mils)	
Left Side	**Right Side**	**Top**	**Bottom**
-7765	7639	5707	-5734
-6943	6855	5138	-5171
-6146	6063	4568	-4601
-5347	5278	3998	-4025
-4555	4503	3426	-3449
-3775	3737	2855	-2873
-3001	2980	2284	-2298
-2239	2228	1714	-1722
-1485	1482	1143	-1147
-741	740	573	-574
0	0	0	0

Horizontal S-Correction User Adjusted using SMfit to Pass IEC

Vertical Lines x-Position (mils)		Horizontal lines y-Position (mils)	
Left Side	**Right Side**	**Top**	**Bottom**
-7663	7484	5707	-5734
-6913	6784	5138	-5171
-6161	6050	4568	-4601
-5391	5305	3998	-4025
-4617	4552	3426	-3449
-3839	3795	2855	-2873
-3064	3036	2284	-2298
-2291	2277	1714	-1722
-1523	1517	1143	-1147
-760	758	573	-574
0	0	0	0

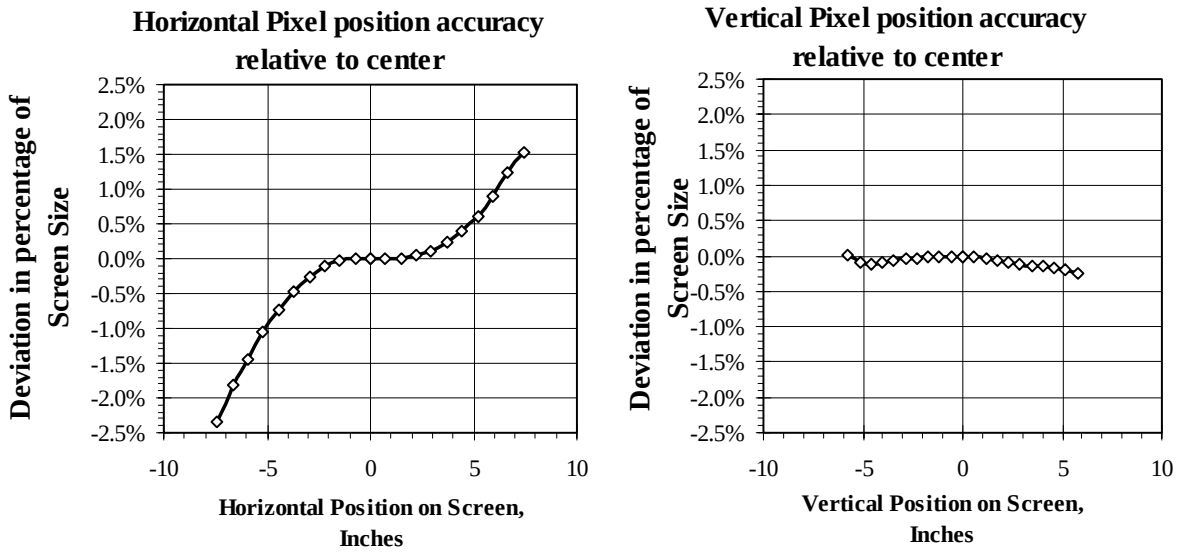


Fig. II.18-5 Horizontal and vertical linearity characteristics using **factory default** setting for which horizontal linearity failed to meet IEC requirements.

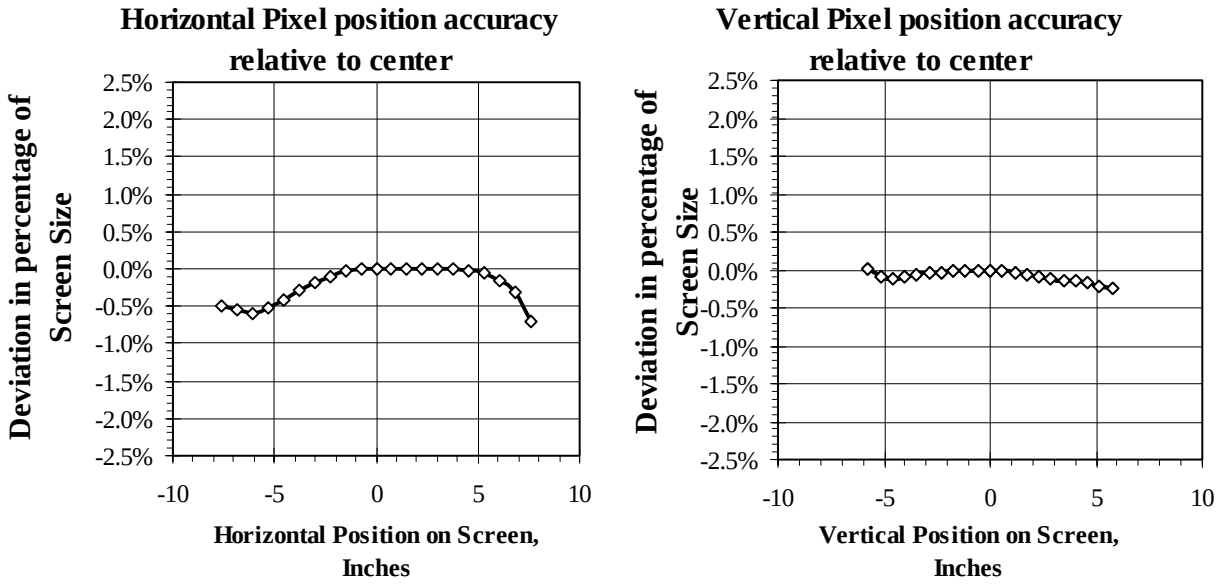


Fig. II.18-6 Horizontal and vertical linearity with **user adjusted** horizontal S-correction using SMfit to pass IEC requirements.

II.19. Jitter/Swim/Drift

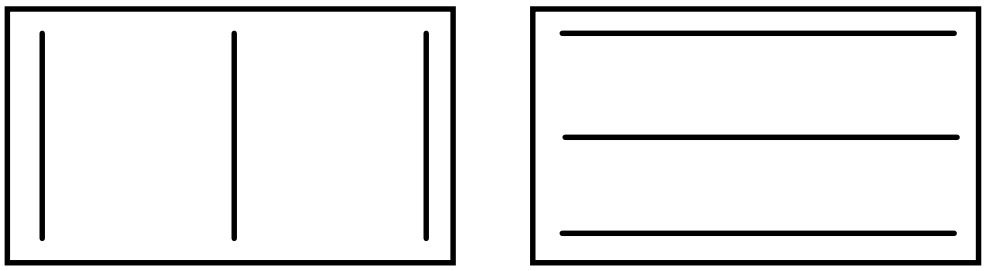
Reference: Monochrome CRT Monitor Performance, Draft Version 2.0 Section 6.4, p 80.

Using factory default settings for monoscopic mode at 1600 x 1200 x 75 Hz, maximum jitter and swim/drift were 1.85 mils and 2.05 mils, respectively.

Objective: Measure amplitude and frequency of variations in beam spot position of the CRT display. Quantify the effects of perceptible time varying raster distortions: jitter, swim, and drift. The perceptibility of changes in the position of an image depend upon the amplitude and frequency of the motions which can be caused by imprecise control electronics or external magnetic fields.

Equipment:
- Video generator
- Spatially calibrated CCD or photodiode array optic module
- Calibrated X-Y translation stage

Test Pattern: Use the three-line grille patterns in Figure II.19-1 for vertical and horizontal lines each 1-pixel wide. Lines in test pattern must be positioned along the top, bottom, and side edges of the addressable screen, as well as along both the vertical and horizontal centerlines (major and minor axes).



V-grille for measuring horizontal motion H-grille for measuring vertical motion

1-pixel wide lines

Three-line grille test patterns.
Figure II.19-1

Procedure: With the monitor set up for intended scanning rates, measure vertical and horizontal line jitter (0.01 to 2 seconds), swim (2 to 60 seconds) and drift (over 60 seconds) over a 2.5 minute duration as displayed using grille video test patterns. Generate a histogram of raster variance with time. The measurement interval must be equal to a single field period.

Optionally, for multi-sync monitors measure jitter over the specified range of scanning rates. Some monitors running vertical scan rates other than AC line frequency may exhibit increased jitter.

Measure and report instrumentation motion by viewing Ronchi ruling or illuminated razor edge mounted to the top of the display. It may be necessary to mount both the optics and the monitor on a vibration damped surface to reduce vibrations.

Data: Tabulate motion as a function of time in x-direction at top-left corner screen location. Repeat for variance in y-direction. Tabulate maximum motions (in mils) with display input count level corresponding to L_{max} for jitter (0.01 to 2 seconds), swim (2 to 60 seconds) and drift (over 60 seconds) over a 2.5 minute duration. The data are presented in Table II.19-1. Both the monitor and the Microvision equipment sit on a vibration-damped aluminum-slab measurement bench. The motion of the test bench was a factor of 10 times smaller than the CRT raster motion.

Table II.19-1. Jitter/Swim/Drift at Top Left

Time scales: Jitter 2 sec., Swim 10 sec., and Drift 60 sec.

		H-lines	V-lines	
10D Corner	Max Motions			
	Jitter	1.53	1.69	
	Swim	1.65	2.32	
	Drift	1.74	2.32	
Black Tape	Max Motions			
	Jitter	0.244	0.263	
	Swim	0.261	0.399	
	Drift	0.405	0.35	
Less Tape Motion				Maximums
	Jitter	1.286	1.427	1.427
	Swim	1.389	1.921	1.921
	Drift	1.335	1.97	1.97

Table II.19-2. Jitter/Swim/Drift at Center Screen

Time scales: Jitter 2 sec., Swim 10 sec., and Drift 60 sec.

		H-lines	V-lines	
Center	Max Motions			
	Jitter	2.07	1.24	
	Swim	2.27	1.42	
	Drift	2.27	1.48	
Black Tape	Max Motions			
	Jitter	0.216	0.19	
	Swim	0.225	0.211	
	Drift	0.245	0.238	
Less Tape Motion				Maximums
	Jitter	1.854	1.05	1.854
	Swim	2.045	1.209	2.045
	Drift	2.025	1.242	2.025

II.20 Warmup Period

Reference: Request for Evaluation Monitors, NIDL Pub. 0201099-091, Section 5.20, p. 10.

Using factory default settings for monoscopic mode at 1600 x 1200 x 75 Hz, a 58 minute warmup was necessary for luminance stability of Lmin = 0.1 fL +/- 10%.

Objective: Define warm-up period

Equipment: Photometer, test target (full screen 0 count)

Procedure: Turn monitor off for three-hour period. Turn monitor on and measure center of screen luminance (Lmin as defined in Dynamic range measurement) at 1-minute intervals for first five minutes and five minute intervals thereafter. Discontinue when three successive measurements are ± 10% of Lmin.

Data: Pass if Lmin within ± 50% in 30 minutes and ±10% in 60 minutes. The luminance of the screen (commanded to the minimum input level, 0 for Lmin) was monitored for 120 minutes after a cold start. Measurements were taken every minute. Figure II.20-1 shows the data for 1600 x 1200 format in graphical form. The luminance remains very stable after 58 minutes.

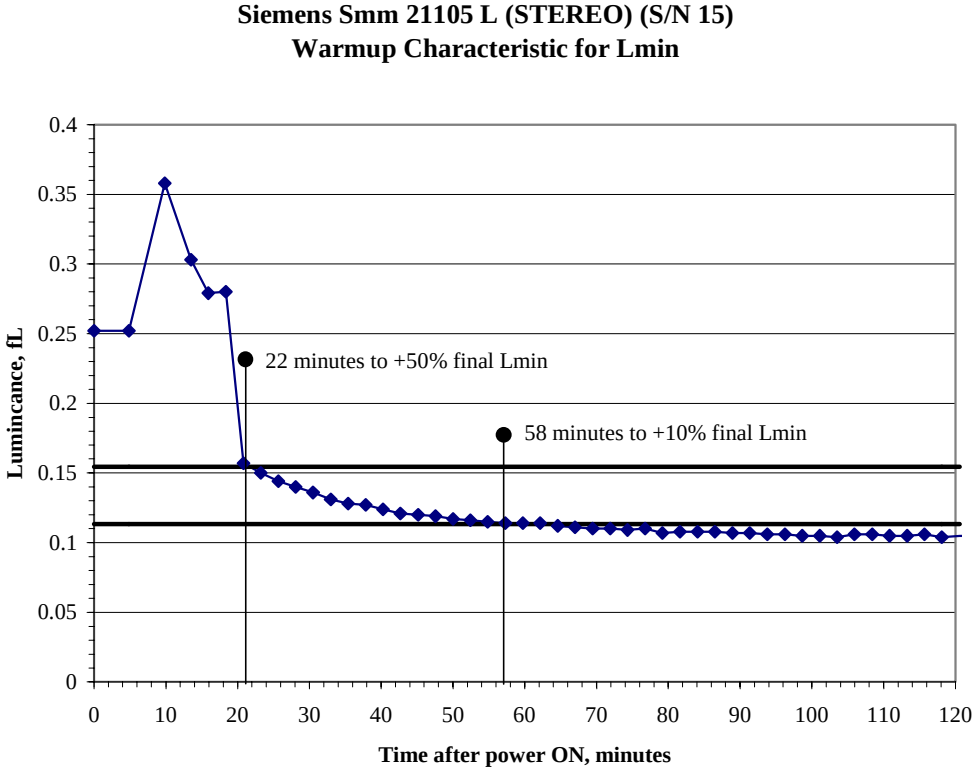


Figure II.20.1. Luminance (fL) as a function of time (in minutes) from a cold start with an input count of 0.

II.21 Separation of Diffuse and Specular Components of Screen Reflectance

*Reference: Monochrome CRT Monitor Performance, Draft Version 2.0 Section 4.5, page 31.**

With the monitor powered off, the total screen reflection was 20.5% as reported in Section II.1. The components of this reflectance measure 7.4% diffuse, 2.1% specular, and 11% from other components such as haze.

Screen reflection factors are calculated from measured luminances reflected by the screen when illuminated by a 700 fL large area (11 x 17.5 inches, H x V) fluorescent light box located 6 feet from the screen. Luminance is measured using a spot photometer with 1° measurement field and a 18% reflective gray card as depicted in Figure II.21-1 for the diffuse reflections, and as depicted in Figure II.21-2 for specular reflections. The procedures, measured values, and calculated reflectances are given on the following page.

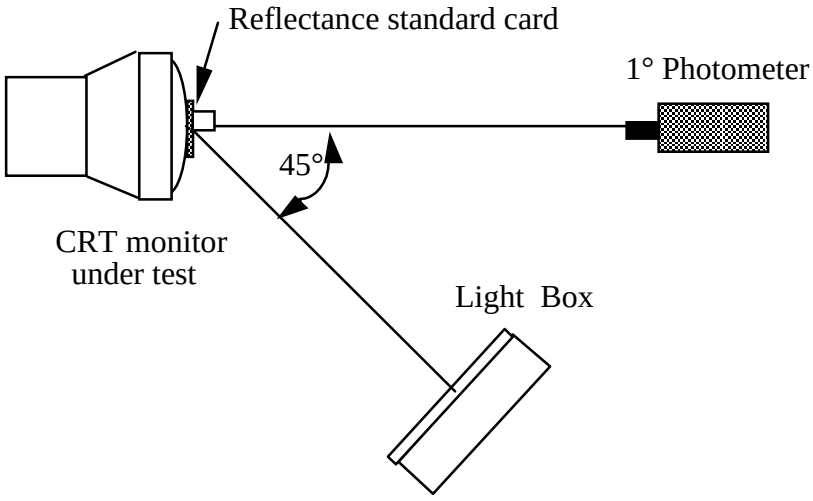


Fig. II.21-1. Test setup for diffuse reflectance measurement.

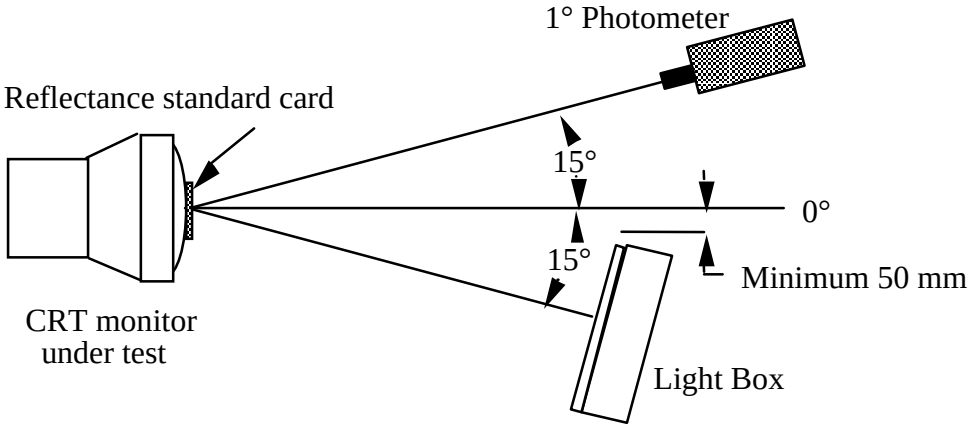


Figure II.21-2. Test setup for specular reflectance measurement.

Procedures and data for measuring reflectance:

** Note: This procedure is undergoing revisions by the International Standards organization (ISO).*

(1) Position the light source (700 fL in this case) from the display screen at an angle of 15° (the specular angle) with respect to the center of the faceplate and with at least 50 mm clearance between the light source and the line perpendicular to the faceplate. Measure $L_{R,specular + diffuse15 + stray15}$ as it is reflected off of the faceplate using a photometer positioned at the opposite -15° angle. 16.88 fL

(2) Without changing the test setup, cover the light source and measure $L_{R,stray15}$. 0 fL

(3) Uncover the light source, reposition the photometer to angle 0°, and measure $L_{R,diffuse15 + stray0}$. 2.49 fL

(4) Without changing the test setup, cover the light source and measure $L_{R,stray0}$. 0 fL

(5) Uncover the light source, reposition it to angle 45°, and measure $L_{R,diffuse45 + stray0}$. 1.62 fL

(6) Position the diffuse reflectance standard (18% reflective in this case, so $q_{diffuse,standard} = 0.18/\pi = 0.0573$) at the center of the display and measure $L_{R,standard45 + standard,stray}$. 1.25 fL

(7) Without changing the test setup, cover the light source and measure $L_{R,standard,stray}$. 0 fL

(8) Calculate the specular reflection factor: 0.021

$$R_{specular} = \{(L_{R,specular + diffuse15 + stray15} - L_{R,stray15}) - (L_{R,diffuse15+stray0} - L_{R,stray0})\}/L_{source}$$

(9) Calculate the diffuse reflection factor: 0.074

$$q_{diffuse} = q_{diffuse,standard} \times \{(L_{R,diffuse45 + stray0} - L_{R,stray0}) / (L_{R,standard45 + standard,stray} - L_{R,standard,stray})\}$$

II.22 Luminance Stability (Lmax)

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0 Section 4.3, p. 26.

FACTORY DEFAULT: Luminance of full screen white in 1024 x 1024 stereo mode is very stable, decreasing by less than 1% from 135.1fL to 133.8 fL as fill factor (target size) was reduced to 10% of full screen.

USER ADJUSTED: With Lmax user adjusted to 250 fL at the CRT screen to achieve IEC required 30 fL threshold at the analyst's eye, maximum luminance decreased during the first 3 hrs by 5.3% from 246 fL to 233 fL. After a three-hour stabilization period, luminance sag is negligible. The luminance remained extremely constant (within <1%) for the remaining 5 hours of the test.

Center screen luminance was measured for different-sized white patches on a black background (different fill factors). The resulting variation in luminance is almost negligible as shown in Figure II.22-1 below.

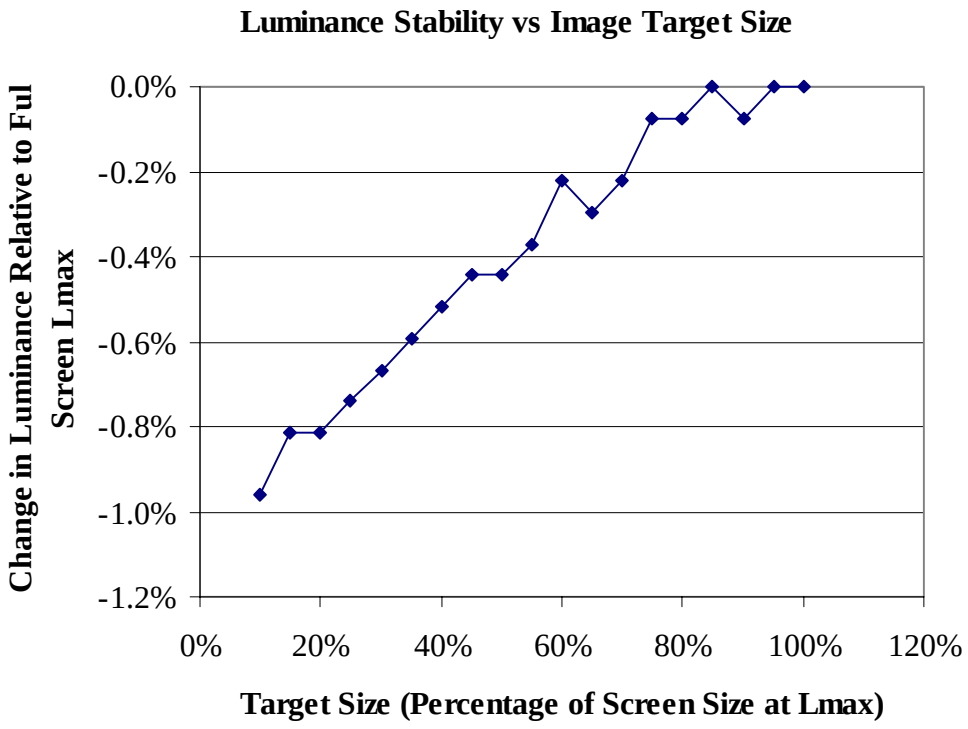


Figure II.22-1. The change in luminance with increasing screen fill factor expressed as a percentage change from the 100% white full screen fill factor luminance level.

With the monitor fully warmed up, center screen luminance was measured as a function of time over an eight hour period while displaying a 100% duty cycle full screen white test pattern displayed at the maximum luminance setting of 250 fL. The data plotted in Figure II.22-2 show a constant decay from 246 fL to 233 fL for the initial three hours during which the full screen white test pattern is displayed. After that, the luminance shifts abruptly to a value of 236 fL and remains extremely constant for the remaining five hours of the test.

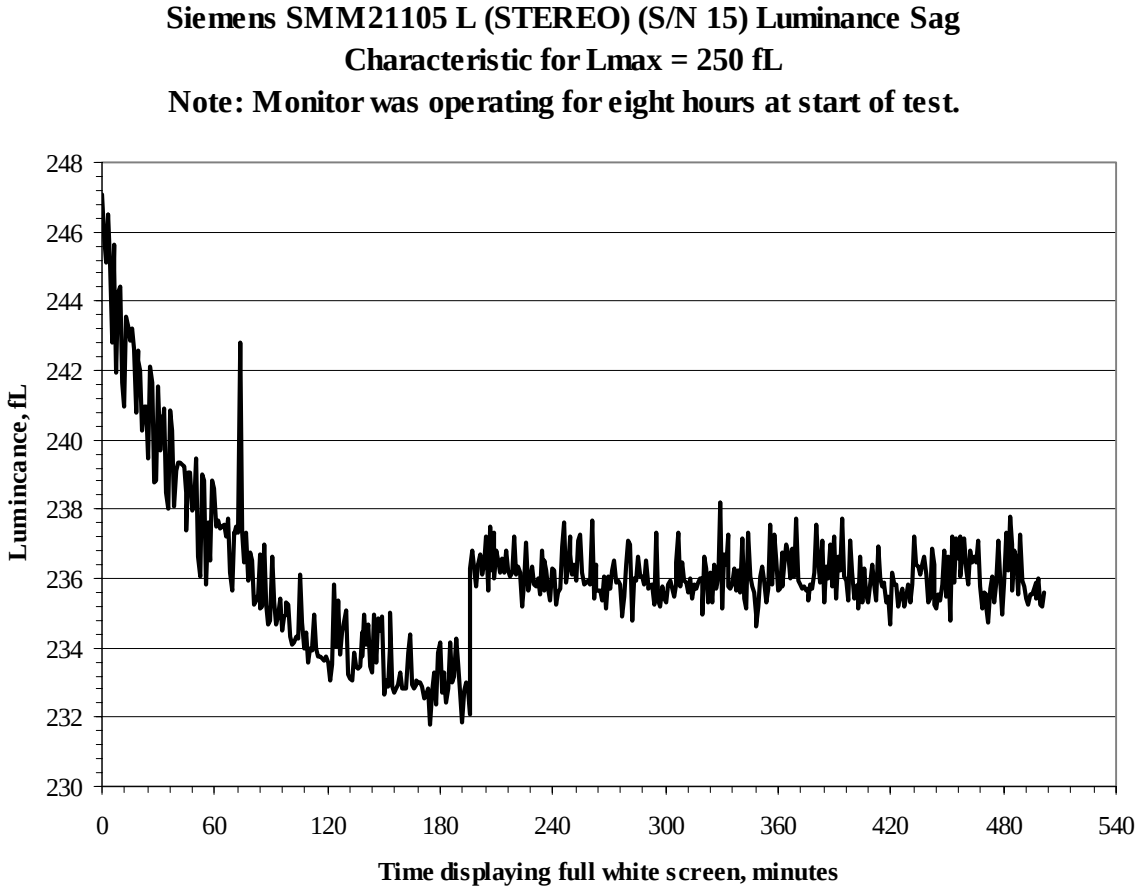


Figure II.22-2. The change in full screen Lmax luminance for 1024 x 1024 x 121 Hz stereoscopic mode and Lmax initially set to 250 fL.

II.23 Briggs Scores

Reference: SofTrak User's Guidelines and Reference Manual version 3.0, NIDL, Sept. 1994, page 3.

FACTORY DEFAULT: For the factory default 1600 x 1200 x 75 Hz monoscopic mode at 37.9 fL, Briggs Scores for the BTP #4 Delta-1, Delta-3, Delta-7 and Delta-15 contrast ratio target sets averaged 15, 58, 69, and 88, respectively.

USER ADJUSTED: For the 1024 x 1024 x 121 Hz stereoscopic mode with Lmax user adjusted to 250 fL at the CRT screen to achieve the IEC required 30 fL threshold at the analyst's eye, Briggs Scores through the ZScreen for the BTP #4 Delta-1, Delta-3, Delta-7 and Delta-15 contrast ratio target sets averaged 19, 57, 64, and 80, respectively.

The 250 fL setting in stereoscopic mode does not seriously degrade Briggs scores compared to the 37.9 fL setting in monoscopic mode.

The Briggs series of test targets illustrated in Figures II.23-1 were developed to visually evaluate the image quality of grayscale monitors. Three NIDL observers (David R. Patterson, Michael H. Brill, Mike Grote) selected the maximum scores for each target set shown in Figure II.23-2 displayed on the Siemens 21105L (Stereo) monochrome CRT monitor driven using a Quantum Data 8701 400MHz programmable test pattern generator. Magnifying devices were used when deemed by the observer to be advantageous in achieving higher scores.

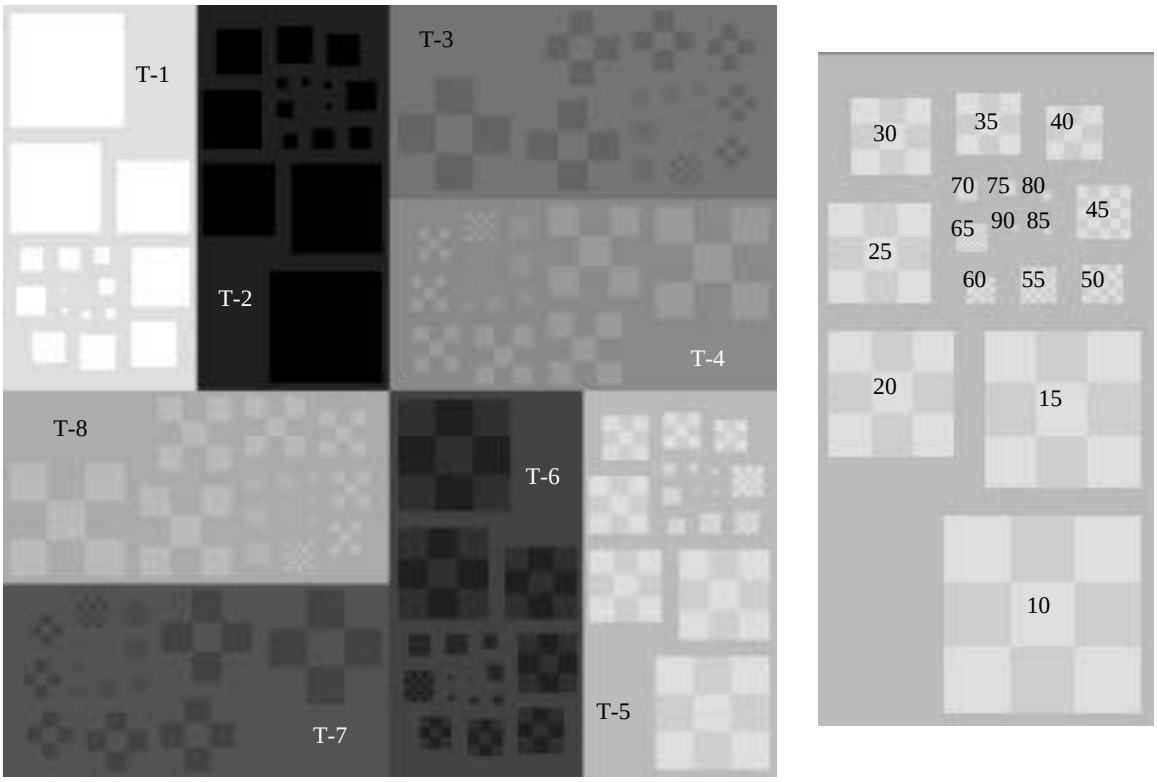


Figure II.23-1. Briggs BPT#4 Test Patterns comprised of 8 targets labeled T-1 through T-8. A series of 17 checkerboards are contained within each of the 8 targets. Each

checkerboard is assigned a score value ranging from 10 to 90. Higher scores are assigned to smaller checkerboards.

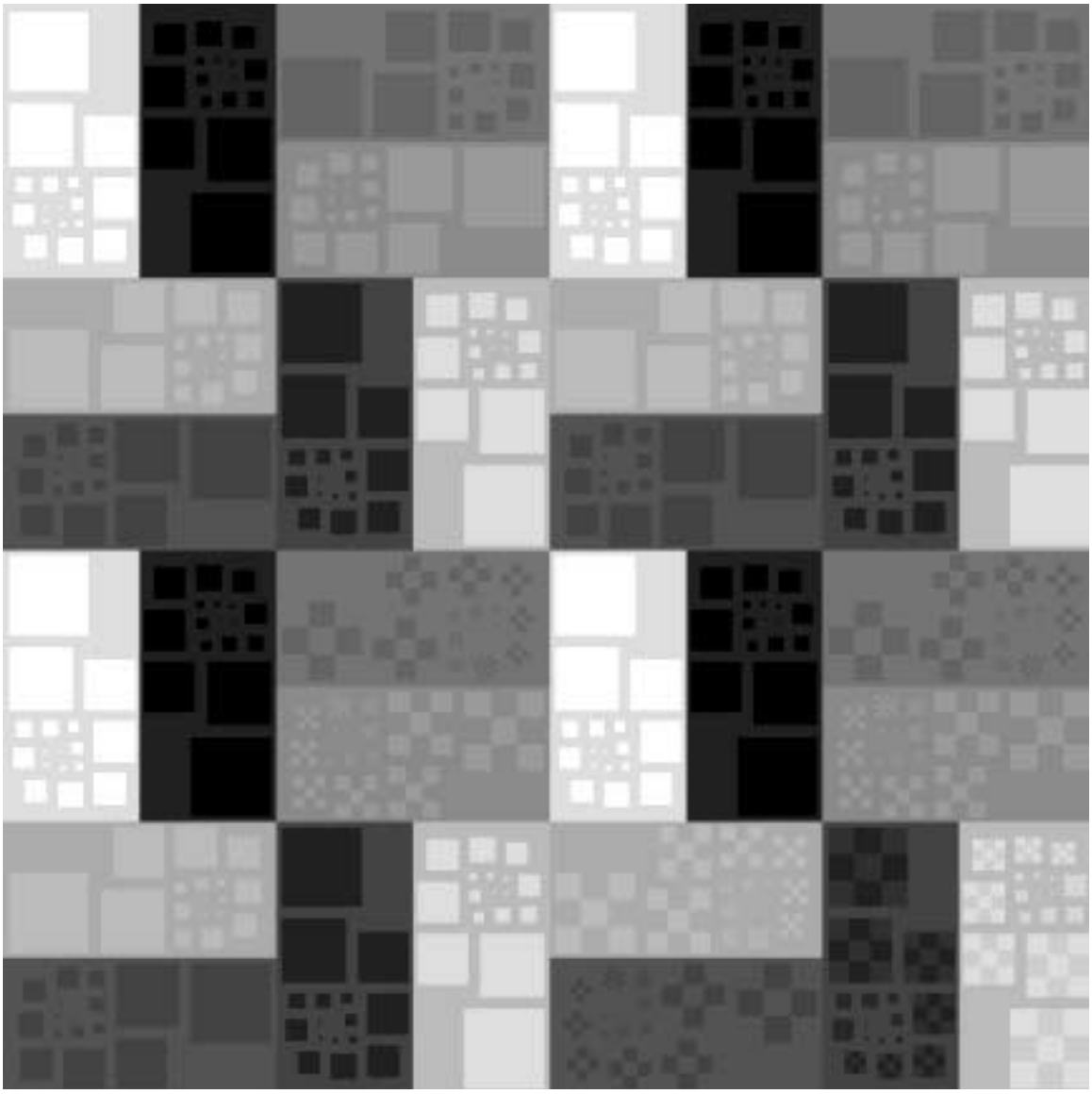


Figure II.23-2. 1024 x 1024 mosaic comprised of four 512 x 512 Briggs BPT#4 Test Patterns. The upper left quadrant contains the set of 8 Briggs targets with command contrast of delta 1. The upper right quadrant contains command contrast of delta 3. Delta 7 targets are in the lower left quadrant and delta 15 targets are in the lower right.

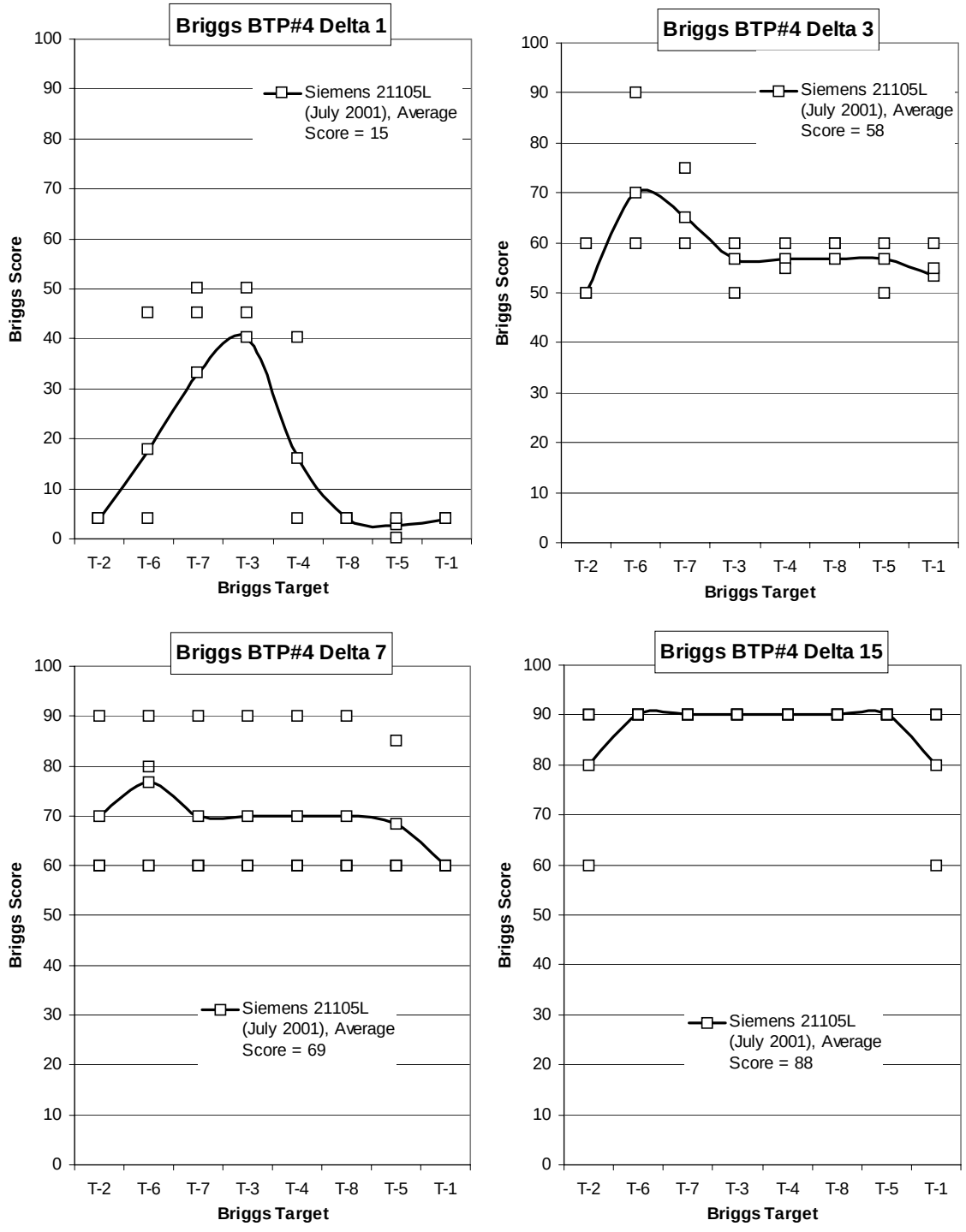


Figure II.23-3. FACTORY DEFAULT: Briggs Scores by three observers for Delta-1, Delta-3, Delta-7 and Delta-15 contrast ratios on BPT#4 Test Pattern for Siemens 21105L (Stereo) monitor operating in factory default 1600 x 1200 x 75Hz monoscopic mode at 37.9 fL.

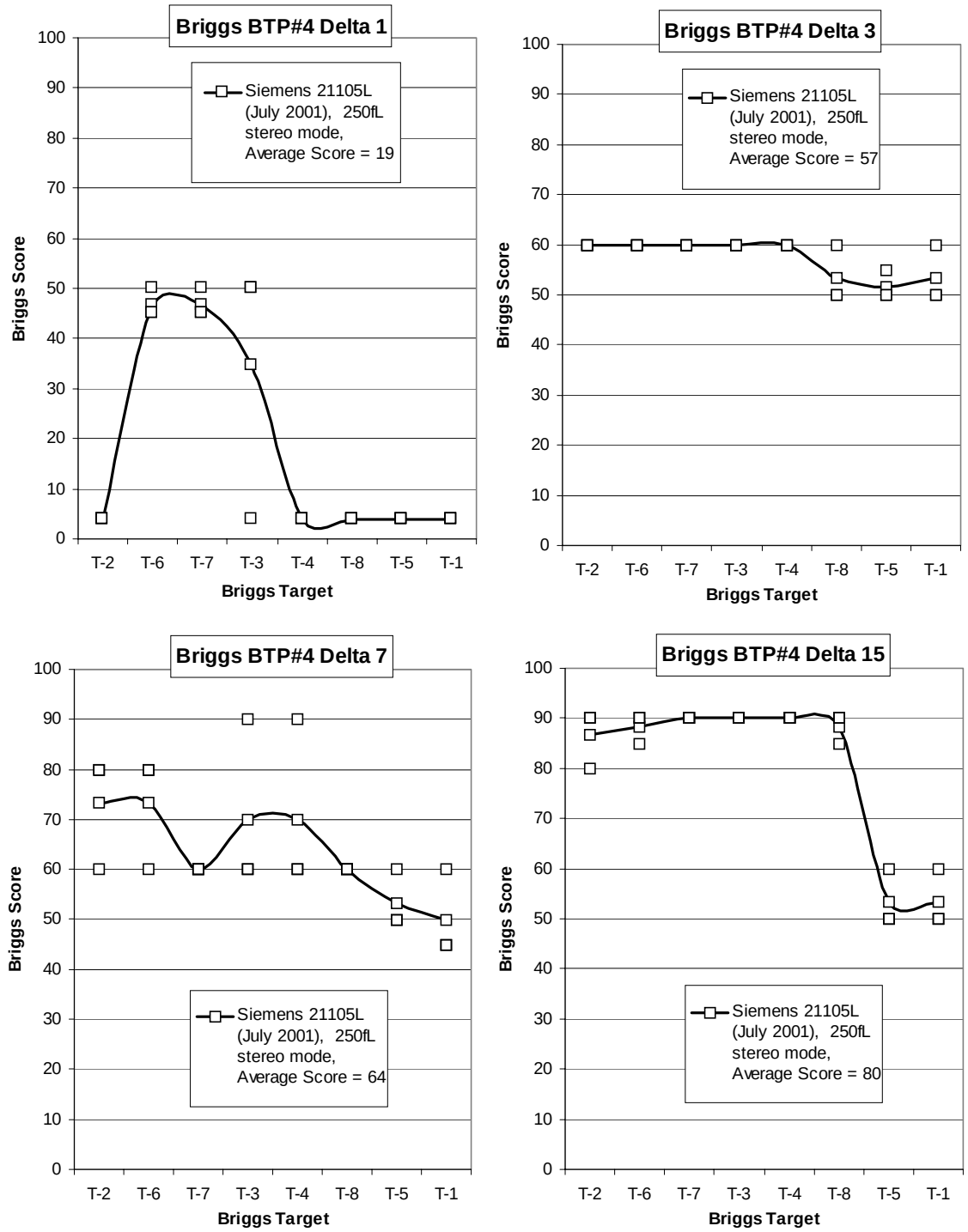


Figure II.23-4. USER ADJUSTED: Briggs Scores by three observers for Delta-1, Delta-3, Delta-7 and Delta-15 contrast ratios on BPT#4 Test Pattern for Siemens 21105L (Stereo) monitor operating in 1024 x 1024 x 121 Hz stereoscopic mode with user adjusted Lmax = 250 fL at the CRT screen to achieve IEC required 30 fL threshold at the analyst's eye.

II. 24 Electron Beam Spot Size

While there are no IEC requirements for spot size and shape measurements, these two parameters directly affect the raster modulation and the 1-on/1-off contrast modulation observed. The intention of the 21105 monitor is to achieve a finer spot size, particularly in monoscopic mode, compared to the 21103 monitor. A finer spot size will improve resolution and, consequently, increase Briggs scores through higher contrast modulation.

FACTORY DEFAULT: Using the factory default setting in 1600 x 1200 monoscopic mode with Lmax = 37.8 fL, the spot size (FWHM) is 7.3 H x 4.6 V mils (RAR = 0.75 H x 0.47 V) at screen center.

Using the factory default setting in 1024 x 1024 stereoscopic mode with Lmax = 136 fL, the spot size (FWHM) is 12.7 H x 6.9 V mils (RAR = 1.08 H x 0.62 V) at screen center.

USER ADJUSTED: In 1024 x 1024 stereoscopic mode with Lmax user adjusted to 250 fL,, the spot size (FWHM) is 16.0 H x 9.2 V mils (RAR = 1.36 H x 0.83 V) at screen center.

For all formats tested, spot shapes exhibit astigmatism in Zone B along the outside edges of the screen.

Spot sizes measured at Lmax for the horizontal (H) and vertical (V) directions in mils at 9 screen positions are measured at the 50% (FWHM) and 5% intensity levels of the spot contours plotted in Figure II.24-1 for 1600 x 1200 x 75 Hz monoscopic mode at 37.8 fL luminance. Spot contours are plotted in Figure II.24-2 for 1024 x 1024 x 121 Hz stereoscopic mode at 136 fL luminance, and plotted in Figure II.24-3 for 1024 x 1024 x 121 Hz stereoscopic mode at 250 fL luminance.

Figures II.24-4 through II.24-9 show the horizontal (H) and vertical (V) spot profiles in mils for each of the spot contours shown in Figures II.24-1 through II.24-3.

For the above measurements, equipment calibrations were first made. These are shown in Figure II.24-10. Spatial calibration of the CCD camera is within 3% for a 10-mil spot.

Table II.24-1. Spot Size Horizontal (H) and vertical (V) spot sizes (in mils) at 9 screen positions are determined at the 50% (FWHM) and 5% intensity levels of the spot contours plotted in Figure II.24-1 for 1600 x 1200 x 75 Hz monoscopic mode at 37.8 fL luminance. Data are plotted in Figure II.24-2 for 1024 x 1024 x 121 Hz stereoscopic mode at 136 fL luminance, and plotted in Figure II.24-3 for 1024 x 1024 x 121 Hz stereoscopic mode at 250 fL luminance.

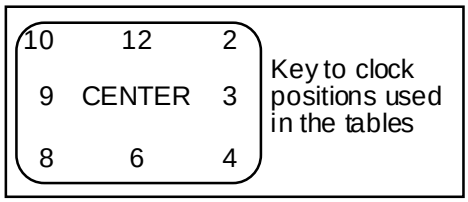
	FACTORY DEFAULT Monoscopic Mode 1600 x 1200 x 75 Hz Lmax = 37.8 fL					
Screen	**Size at 50%**		**Size at 5%**		**RAR**	
Position	**H**	**V**	**H**	**V**	**H**	**V**
Ctr	7.3	4.6	15.4	11.1	0.75	0.47
2	9.5	8.3	20.9	20.7	0.98	0.85
3	10.4	5.1	20.0	18.9	1.08	0.52
4	11.3	9.2	21.8	21.2	1.17	0.95
6	7.3	6.0	16.3	12.9	0.75	0.62
8	10.4	6.0	25.4	15.2	1.08	0.62
9	10.9	5.1	21.3	19.8	1.12	0.52
10	8.6	8.3	21.3	22.6	0.89	0.85
12	7.3	5.5	16.8	14.3	0.75	0.57
Average	9.2	6.4	19.9	17.4	0.95	0.66
Min	7.3	4.6	15.4	11.1	0.75	0.47
Max	11.3	9.2	25.4	22.6	1.17	0.95
Range	44%	71%	50%	66%	44%	71%

FACTORY DEFAULT
Stereoscopic Mode
1024 x 1024 x 121 Hz
Lmax = 136 fL

Screen	Size at 50%		Size at 5%		RAR	
Position	H	V	H	V	H	V
Ctr	12.7	6.9	20.4	14.7	1.08	0.62
2	11.8	8.7	26.3	24.9	1.00	0.79
3	14.1	5.5	23.6	19.8	1.19	0.50
4	13.6	10.1	25.0	24.4	1.16	0.91
6	11.3	8.7	19.1	17.0	0.96	0.79
8	12.3	8.3	30.0	17.0	1.04	0.75
9	13.2	6.0	23.1	22.1	1.12	0.54
10	10.4	8.1	29.5	27.6	0.89	0.72
12	9.5	7.4	21.3	16.1	0.81	0.66
Average	12.1	7.8	24.3	20.4	1.03	0.70
Min	9.5	5.5	19.1	14.7	0.81	0.50
Max	14.1	10.1	30.0	27.6	1.19	0.91
Range	38%	59%	45%	63%	38%	59%

USER ADJUSTED
Stereoscopic Mode
1024 x 1024 x 121 Hz
User Adjusted for Lmax = 250 fL

Screen	Size at 50%		Size at 5%		RAR	
Position	H	V	H	V	H	V
Ctr	16.0	9.2	23.8	20.7	1.36	0.83
2	15.5	11.1	30.6	30.8	1.32	0.99
3	18.3	9.2	27.9	27.6	1.55	0.83
4	17.8	13.4	31.1	31.8	1.51	1.20
6	13.7	12.0	25.1	23.9	1.16	1.08
8	15.5	12.4	38.9	23.9	1.32	1.12
9	16.5	7.8	26.1	27.6	1.40	0.70
10	13.3	9.7	31.1	30.8	1.12	0.87
12	13.7	10.6	25.6	20.7	1.16	0.95
Average	15.6	10.6	28.9	26.4	1.32	0.95
Min	13.3	7.8	23.8	20.7	1.12	0.70
Max	18.3	13.4	38.9	31.8	1.55	1.20
Range	32%	52%	52%	42%	32%	52%



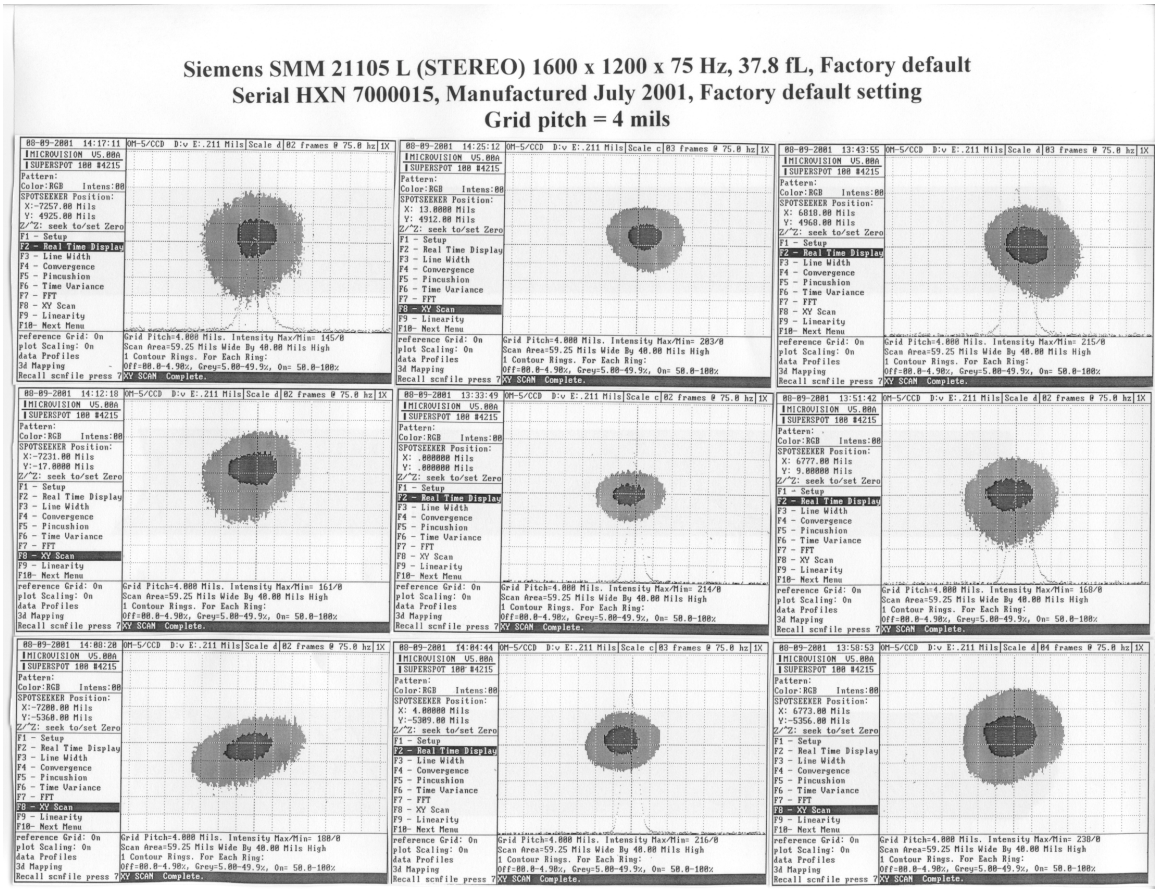


Figure II.24-1. Spot contour plots of the Siemens SMM 21105 L (STEREO) monitor operating in 1600 x 1200 x 75 Hz monoscopic mode at 37.8 fL. The outer contour is the 5% intensity level of the spot. The inner contour is the FWHM or 50% intensity level. Screen positions are represented by the position of the spot picture in the figure. The grid pitch is 4 mils. For the measurements, a camera with CCD element size as projected on the CRT screen is 0.21 mils.

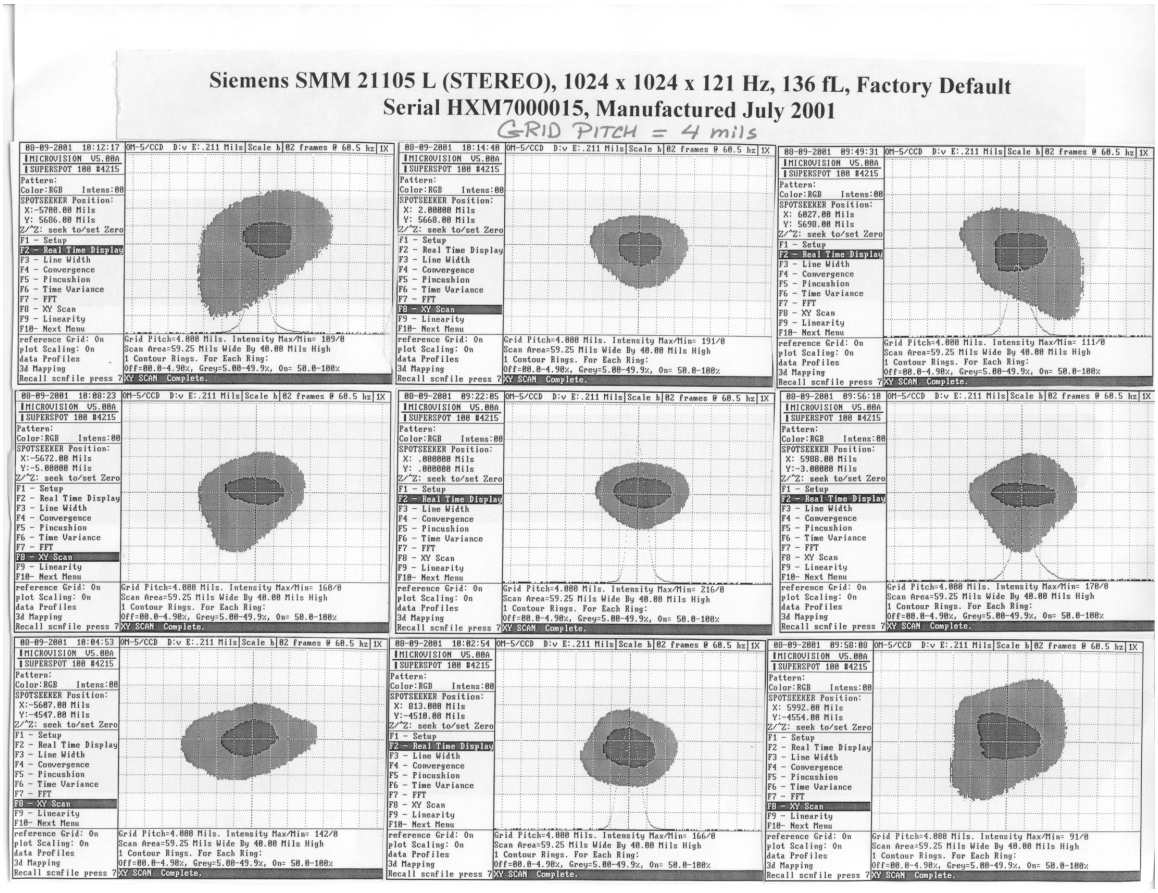


Figure II.24-2. Spot contour plots of the Siemens SMM 21105 L (STEREO) monitor operating in 1024 x 1024 x 121 Hz stereoscopic mode at 136 fL. The outer contour is the 5% intensity level of the spot. The inner contour is the FWHM or 50% intensity level. Screen positions are represented by the position of the spot picture in the figure. The grid pitch is 4 mils. For the measurements, a camera with CCD element size as projected on the CRT screen is 0.21 mils.

SIEMENS SMM21105 L (Stereo) 1024 x 1024 x 121 Hz at 250 FL
Date of Manufacture July 01 Serial Number HXN 7000015 Type 6GF6300-1BU03
Grid Pitch = 4 mils

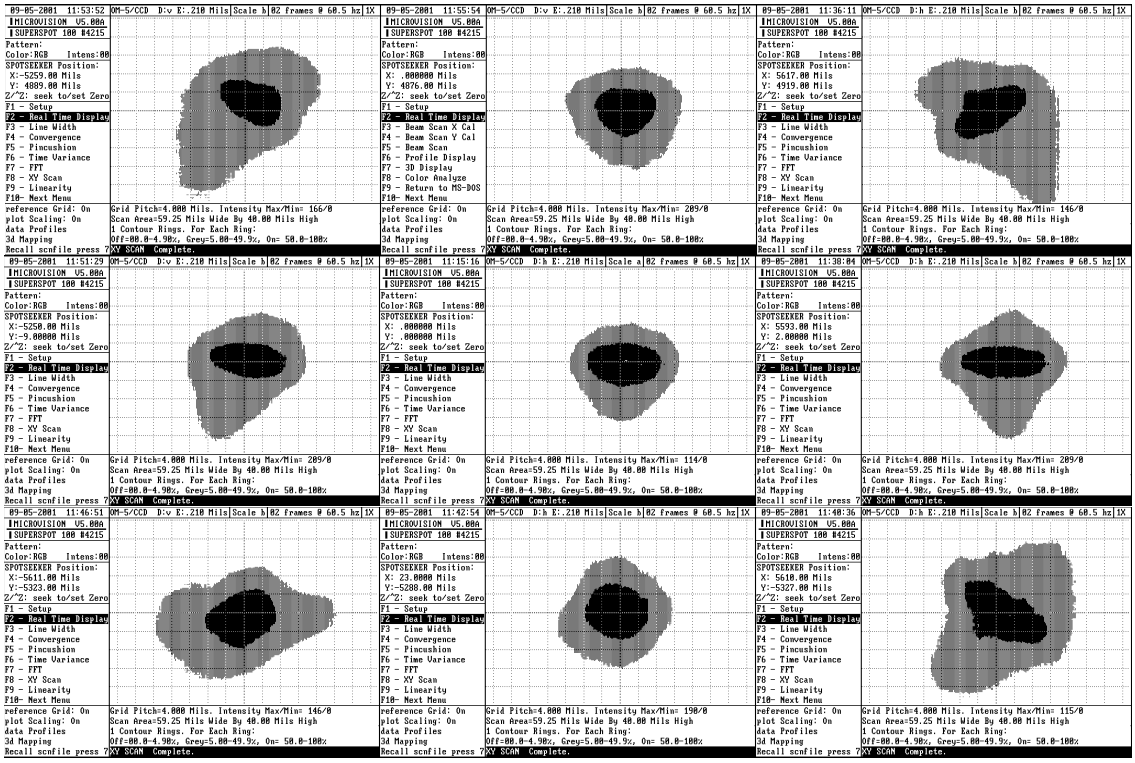


Figure II.24-3. Spot contour plots of the Siemens SMM 21105 L (STEREO) monitor operating in 1024 x 1024 x 121 Hz stereoscopic mode at Lmax = 250fL. The outer contour is the 5% intensity level of the spot. The inner contour is the FWHM or 50% intensity level. Screen positions are represented by the position of the spot picture in the figure. The grid pitch is 4 mils. For the measurements, a camera with CCD element size as projected on the CRT screen is 0.21 mils.

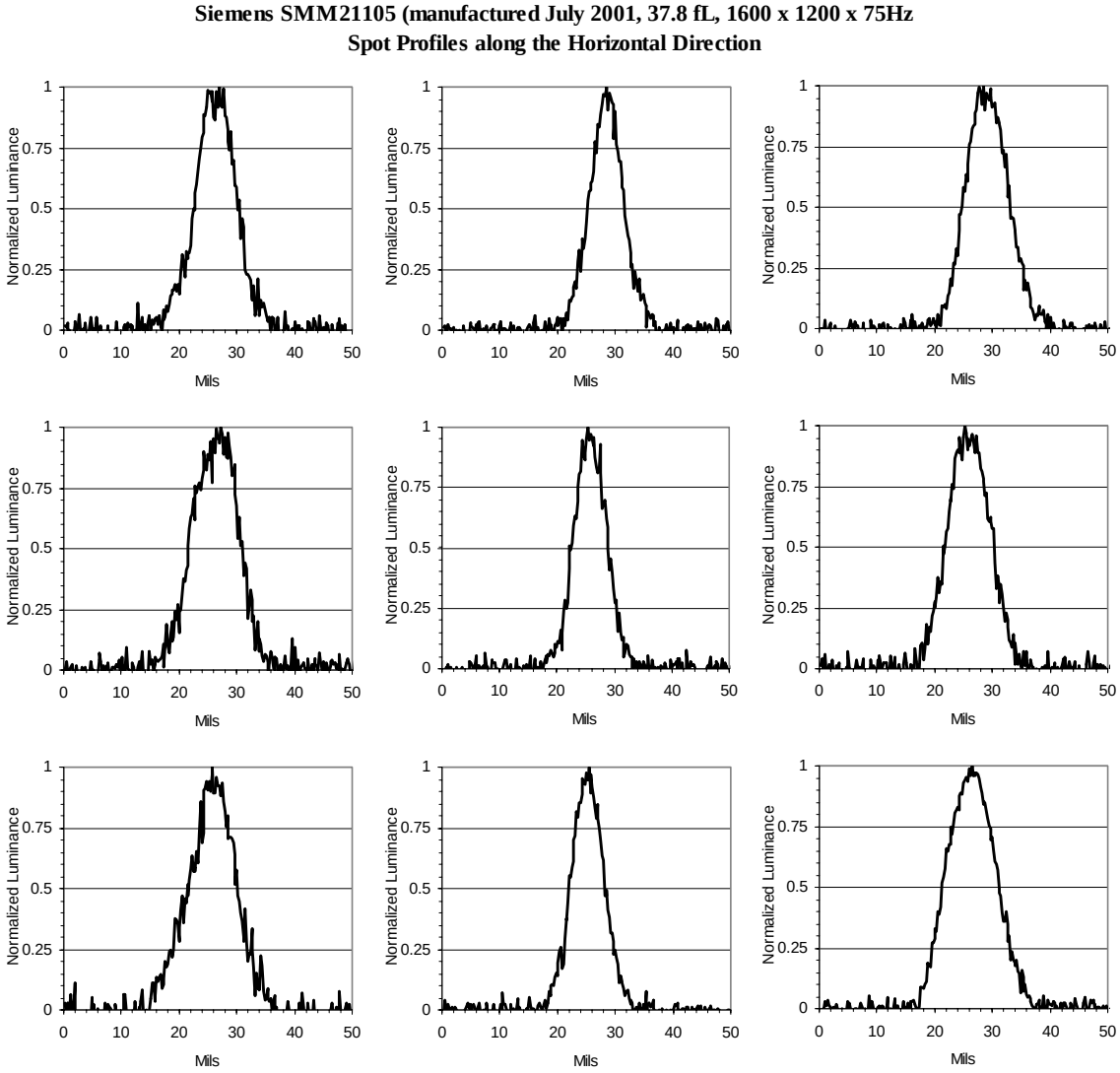


Figure II.24-4. Luminance profiles at 37.8 fL for 1600 x 1200 x 75 Hz monoscopic mode along the horizontal direction of spots of the Siemens 21105L Stereo monitor (manufactured July 2001) as a function of position on the screen. Screen positions are represented by the position of the spot picture in the figure.

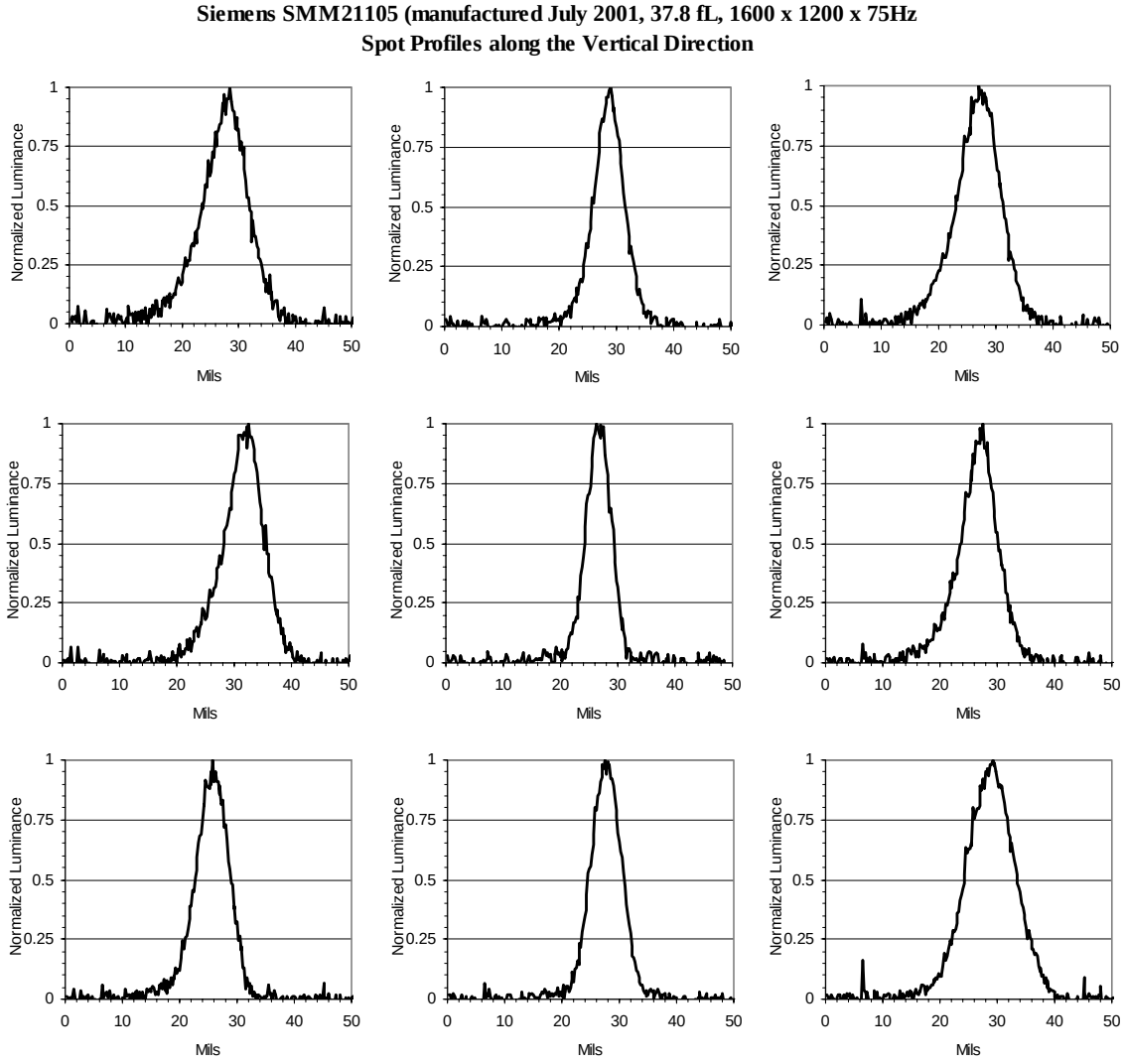


Figure II.24-5. Luminance profiles at 37.8 fL for 1600 x 1200 x 75 Hz monoscopic mode along the vertical direction of spots of the Siemens 21105L Stereo monitor (manufactured July 2001) as a function of position on the screen. Screen positions are represented by the position of the spot picture in the figure.

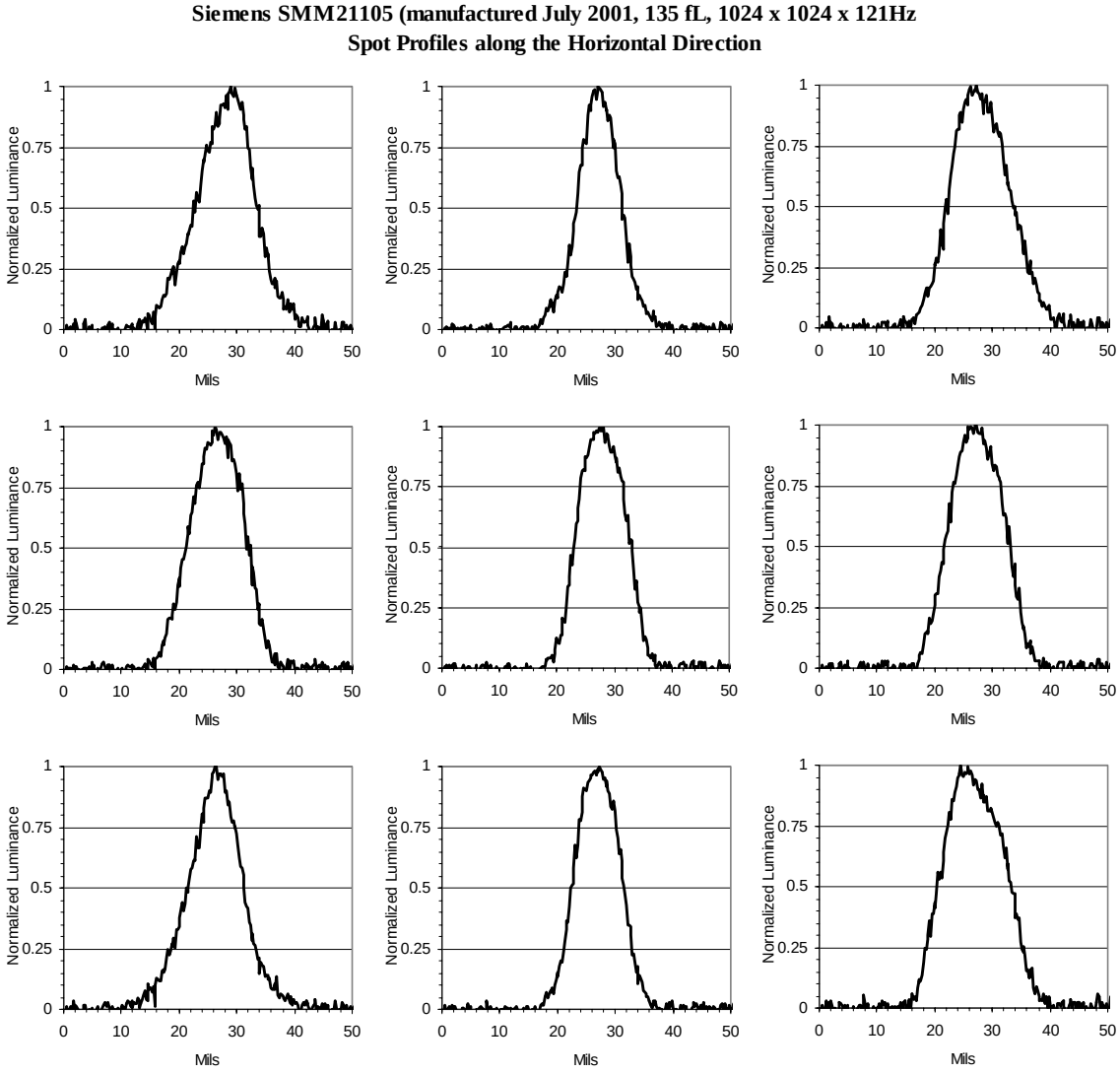


Figure II.24-6. Luminance profiles at 135 fL for 1024 x 1024 x 121 Hz stereoscopic mode along the horizontal direction of spots of the Siemens 21105L Stereo monitor (manufactured July 2001) as a function of position on the screen. Screen positions are represented by the position of the spot picture in the figure.

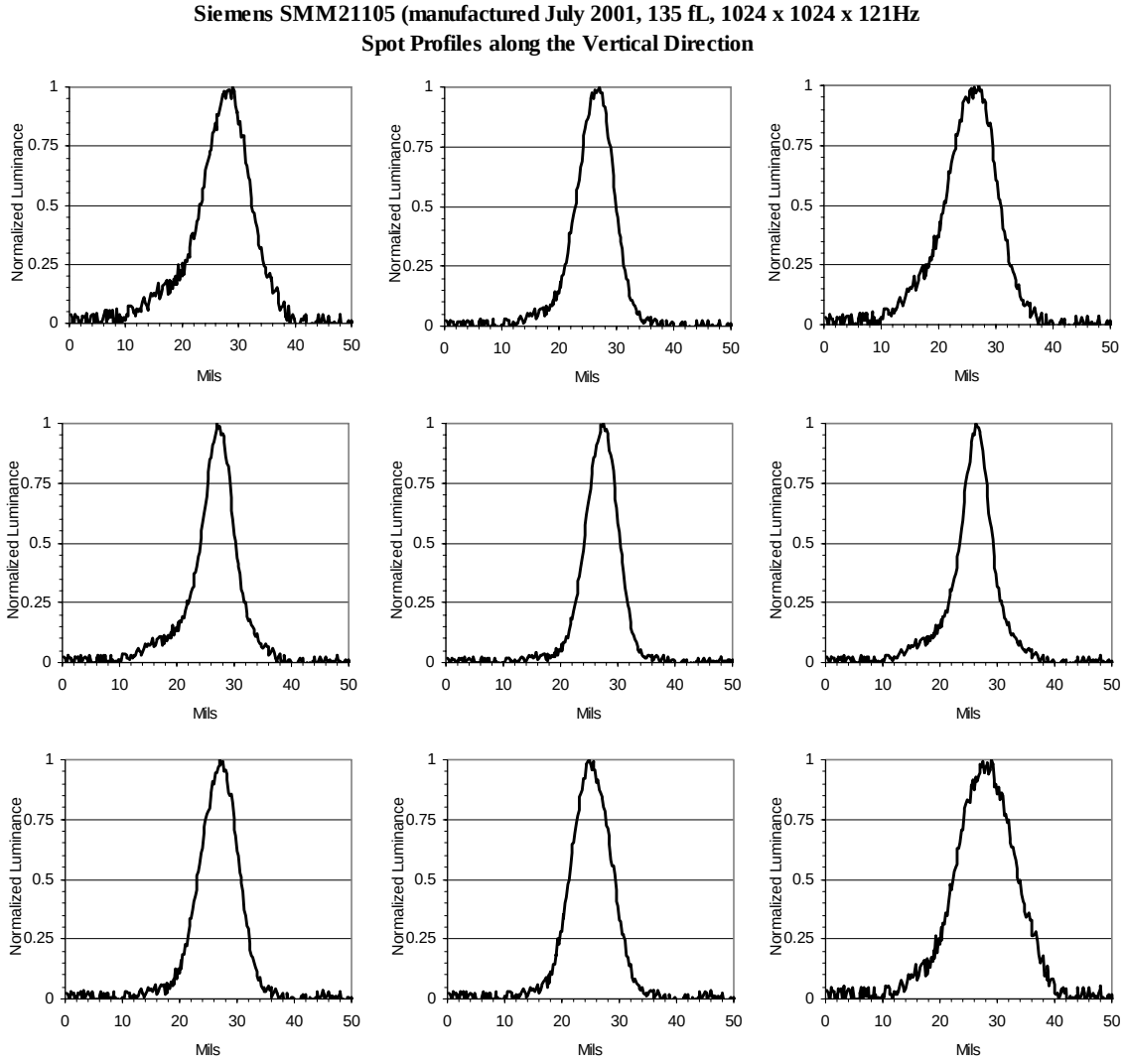


Figure II.24-7. Luminance profiles at 135 fL for 1024 x 1024 x 121 Hz stereoscopic mode along the vertical direction of spots of the Siemens 21105L Stereo monitor (manufactured July 2001) as a function of position on the screen. Screen positions are represented by the position of the spot picture in the figure.

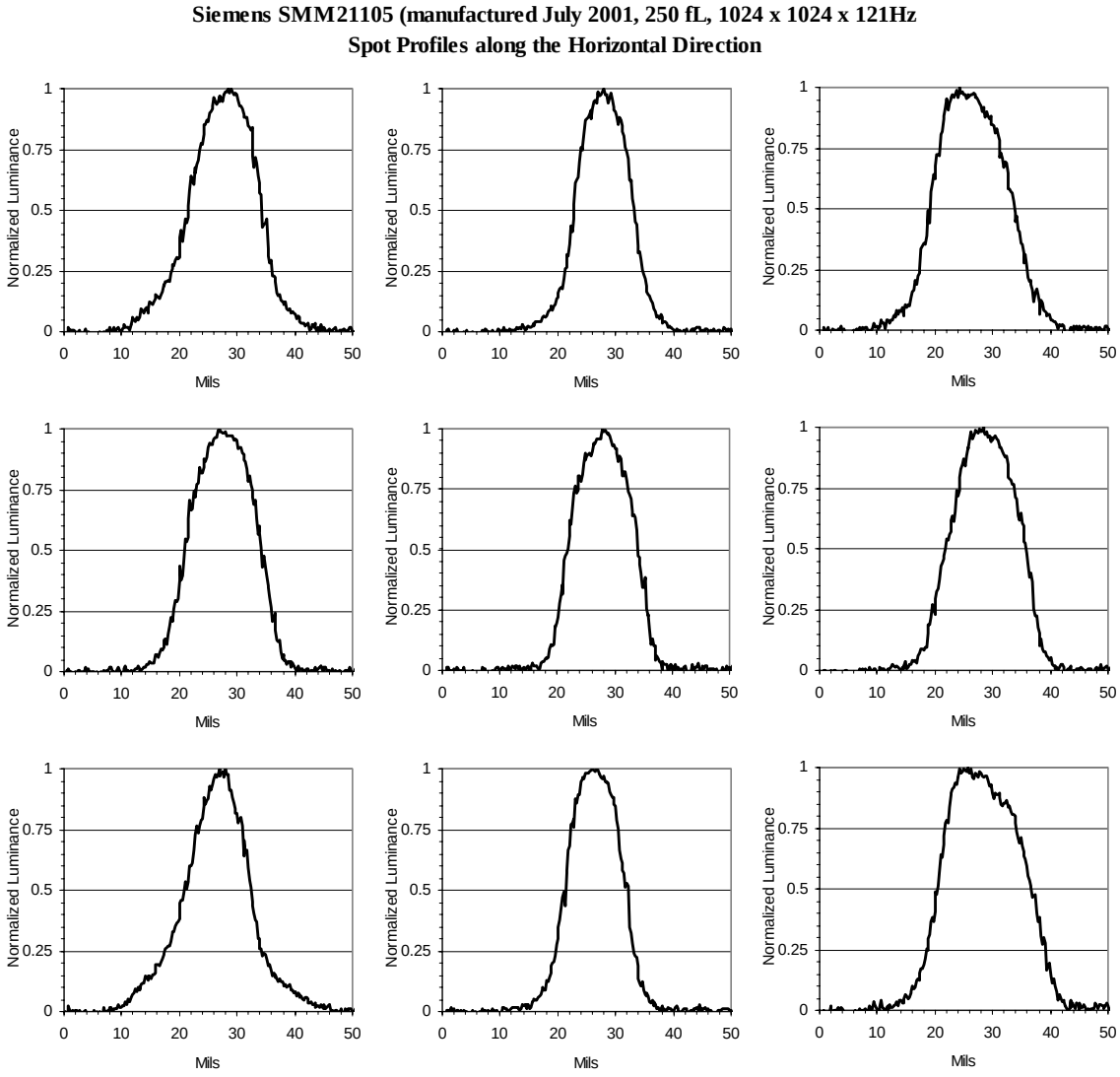


Figure II.24-8. Luminance profiles at 250 fL for 1024 x 1024 x 121 Hz stereoscopic mode along the horizontal direction of spots of the Siemens 21105L Stereo monitor (manufactured July 2001) as a function of position on the screen. Screen positions are represented by the position of the spot picture in the figure.

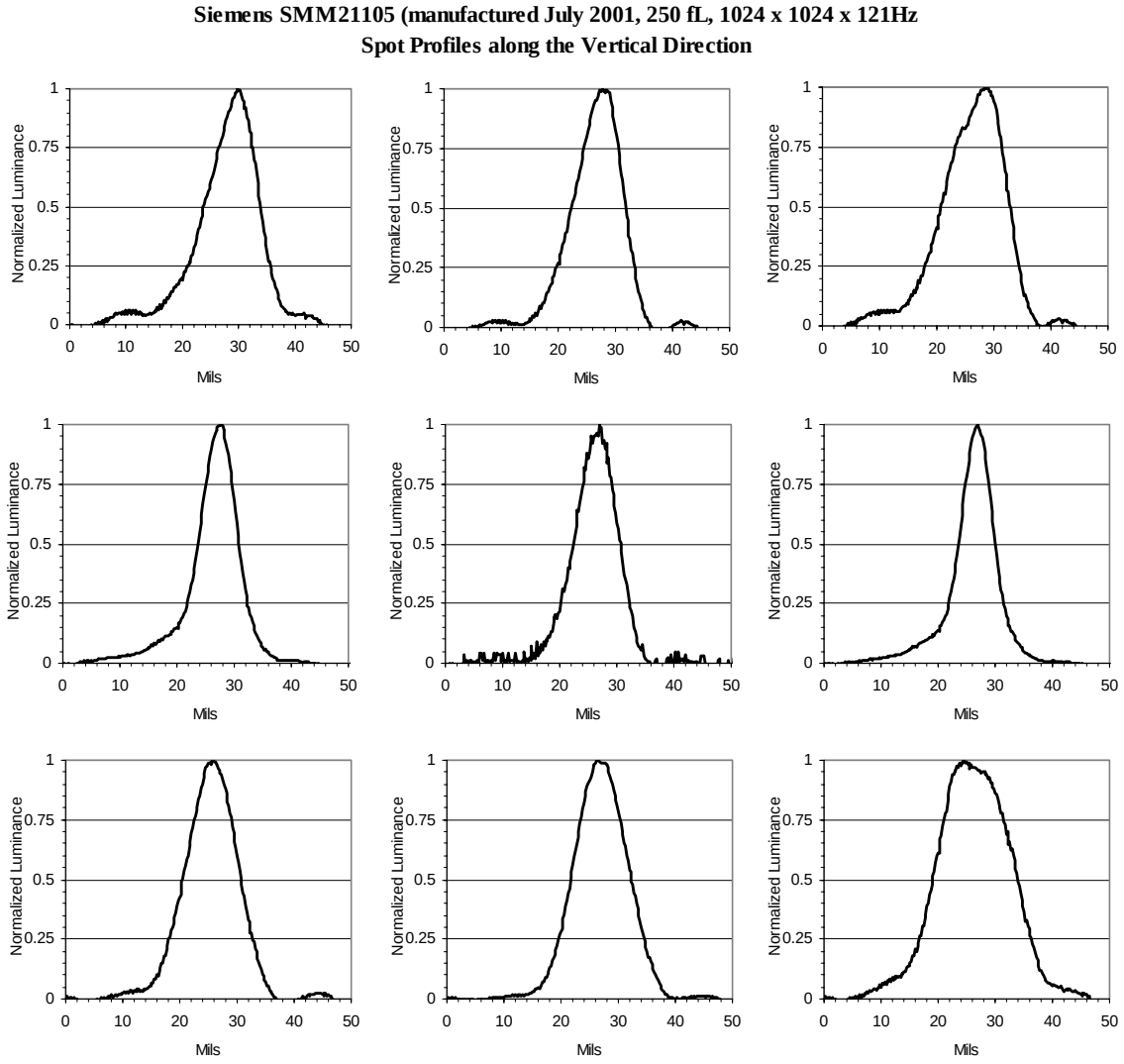
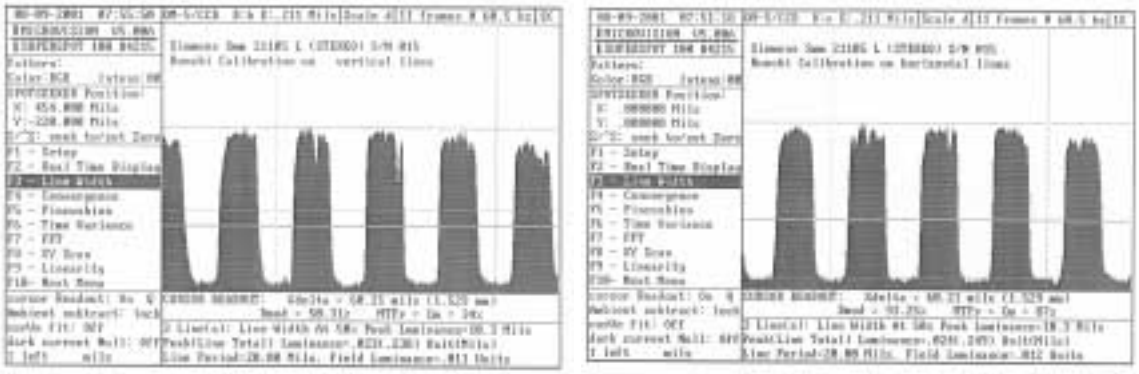


Figure II.24-9. Luminance profiles at 250 fL for 1024 x 1024 x 121 Hz stereoscopic mode along the vertical direction of spots of the Siemens 21105L Stereo monitor (manufactured July 2001) as a function of position on the screen. Screen positions are represented by the position of the spot picture in the figure.



Horizontal Direction **Vertical Direction**

Figure II.24-10. Luminance profiles for Ronchi ruling showing spatial calibration of the CCD camera used to measure spot contours. The Ronchi ruling is comprised of 10-mil wide opaque black stripes spaced 10-mils apart.

II. 25 Electron Beam Linewidth

Reference: Monochrome CRT Monitor Performance, Draft Version 2.0 Section 5.1, page 47.

FACTORY DEFAULT: Linewidths (full width half maximum) were measured at screen center for four luminance settings in the 1600 x 1200 x 75 Hz monoscopic mode. They are 7.84 mils Horizontal x 5.58 mils Vertical at 50% Lmax (19 fL) for a Resolution-Addressability-Ratio of 0.81 H x 0.57 V in monoscopic mode (1600 x 1200).

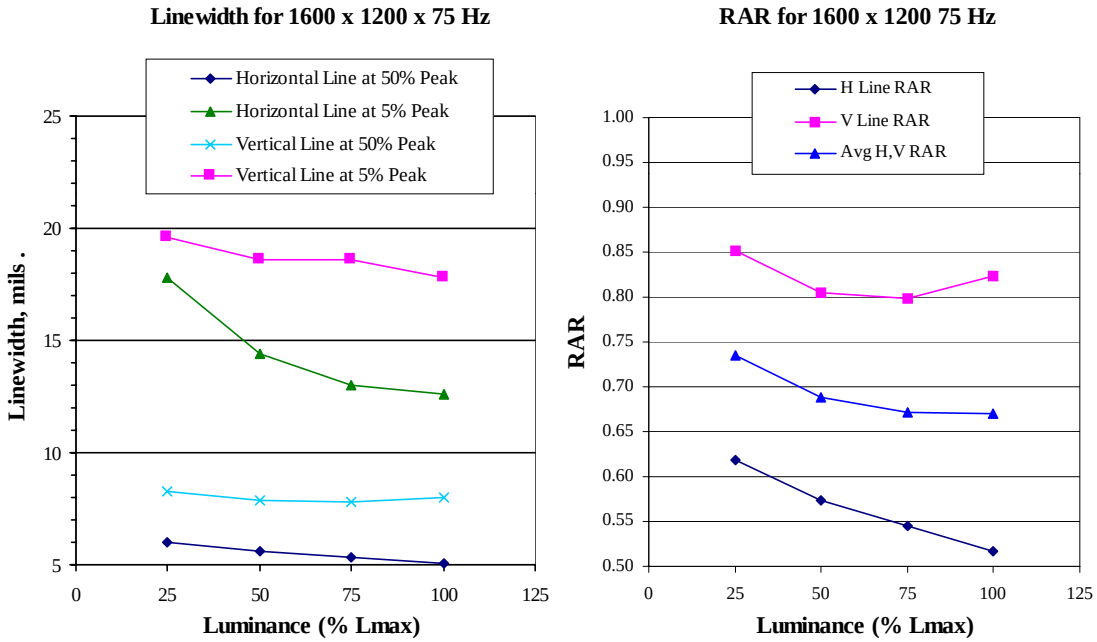


Figure II.25-1. Linewidth (mils) and RAR (Resolution Addressability Ratio) as a function of position on the screen.

Table II.25-1. Linewidths at Screen Center

	HORIZONTAL (Vertical Line)			VERTICAL (Horizontal Line)			Resolution-Addressability-Ratio (RAR)		
Luminance	**50%**	**10%**	**5%**	**50%**	**10%**	**5%**	**H**	**V**	**Avg H,V**
25% Lmax	8.29	16.40	19.60	6.03	11.50	17.80	0.85	0.62	0.74
50% Lmax	7.84	15.50	18.60	5.58	11.30	14.40	0.81	0.57	0.69
75% Lmax	7.77	15.40	18.60	5.32	10.90	13.00	0.80	0.55	0.67
100% Lmax	8.02	15.10	17.80	5.04	10.50	12.60	0.82	0.52	0.67